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VOLUME 15, NUMBER 1
MARCH, 1954

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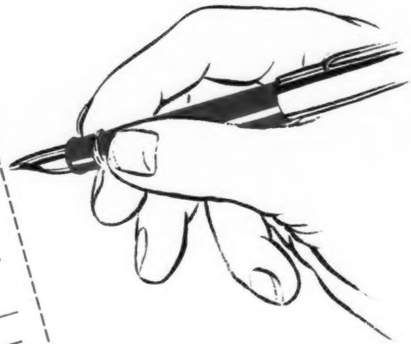

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AMERICAN INDUSTRIAL HYGIENE ASSOCIATION *Quarterly*

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Errors Due to Anisokinetic Sampling of Aerosols

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Isokinetic flow conditions at a sampling orifice are well understood to be necessary for quantitative sampling of an aerosol from a moving air-stream. Never, however, are such conditions completely achieved, often not even approximately. Hence, it becomes necessary to investigate the errors involved and to design sampling equipment such that the errors due to unavoidable anisokinetic conditions are reduced to a minimum. Experimental data are few, and it is not possible therefore to estimate the error under any set of specified conditions. Isokinetic conditions will occur only when the stream lines of flow of the environment carrying the aerosol enter the orifice without disturbance or acceleration of any kind. That is to say, there must be no eddy formation at or near the orifice, no change of direction as the air carrying the aerosol enters the orifice, no convergence nor divergence; furthermore, the air of the environment must be flowing uniformly without turbulence.

It is the purpose of this paper to present a tentative semi-empirical theory, which has been developed from the results of a few recent experiments, and to review briefly the available data.

Theoretical Considerations

Consider a circular sampling tube of internal diameter D, and wall thickness W, with its axis at an angle θ to the direction of flow of the air of the environment in which it is placed (Fig. 1).

If Q is the rate at which air is drawn through the tube, the mean velocity across any cross section of the tube is given by

$$\overline{U} = 4Q/\pi D^2 \tag{1}$$

Below the critical Reynolds number (about 2000 for a smooth circular tube) the flow will tend, at a sufficient distance from the orifice, to a parabolic distribution, with axial velocity equal to $2\overline{U}$. The higher the Reynolds number and the closer to the orifice, the more uniform will be the velocity profile.

Consider a particle (a sphere of diameter d and density ρ) which enters the "zone of influence" of the sink provided by the sampling orifice. The problem becomes one of determining whether or not the particle will enter the orifice. Ignoring, for the moment, the vertical distance fallen at its terminal velocity, the particle will certainly be sampled when conditions are strictly isokinetic. If the particles of an aerosol being sampled are uniformly distributed throughout the environment, then it can be assumed that for every particle of a given size that falls vertically a distance large enough to escape entering the orifice under isokinetic conditions, another particle will enter the zone of influence to take its place.

If conditions are anisokinetic, particles

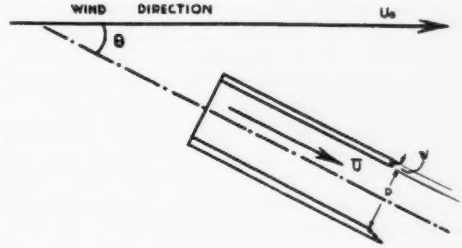
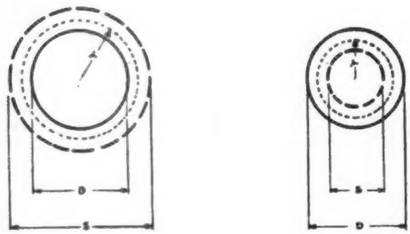


Fig. 1.
Diagram of sampling tube (general arrangement).



(a) $U_0 < \bar{U}$ (b) $U_0 > \bar{U}$

Fig. 2.
Diagrams to represent the parameter S.

have to be accelerated in order that they can enter the orifice. The following parameters may be expected to play a part in determining the sampling efficiency:

(a) U_0, the stream velocity
(b) $\bar{U}$, the mean air velocity at the sampling orifice
(c) θ, the angle between U_0 and $\bar{U}$
(d) D, the diameter of the orifice
(e) W, the wall thickness (bluffness at orifice and the disturbance due to other parts of the sampling equipment will affect the overall flow pattern)
(f) $d\rho^{1/2}$, the aerodynamic diameter of the particle (this requires special consideration for a non-spherical particle)
(g) η, the viscosity of the fluid carrying the aerosol

We may write:

$$\frac{4Q}{\pi} = D^2\bar{U} = S^2U_0 \tag{2}$$

where S can be considered the diameter of a cylinder of air, moving with velocity U_0 that converges (when $S>D$) or diverges (when $S<D$) to the orifice (Fig. 2). Using this simplified picture, the problem reduces to a consideration as to whether a particle can move a radial distance $\frac{S-D}{2}$ (or $\frac{D-S}{2}$) and enter the orifice (or escape). Particles of negligible inertia (e.g., air molecules) will do so. For a very large particle, one which does not deviate at all from its original direction of motion, the sampling efficiency is seen, when $\theta = 0$, to be

$$\frac{C}{C_0} = \frac{D^2}{S^2} = \frac{U_0}{\bar{U}} \tag{3}$$

where C is the concentration measured and C_0 is the true concentration.

Thus, where $\theta = 0$, C/C_0 will lie between unity and $U_0/\bar{U}$. (See below for consideration of conditions when U_0 or $\bar{U}$ tend to zero). Its actual value can be equated to:

$$C/C_0 = U_0/\bar{U} \pm K \tag{4}$$

where K depends on particle size and is pictured as proportional to the area of an annulus of outer radius, r, such that a particle of given size will move a distance across from its original radial position, given by:

$r - D/2$ (for $S>D$)
$r - S/2$ (for $S<D$)

It remains to determine r, and hence K.

The number of particles of a given size that pass at a velocity U_0, in unit time, through an annulus of limiting radii r and $r + dr$ is

$$2\pi r \,.\, dr \,.\, U_0 N$$

where N is the number per unit volume of particles of the size being considered. We may take the dimensionless particle inertial parameter

$$p = \frac{d^2 \rho U_0}{18\eta L}$$

as a measure of the resistance to change of movement at right angles to the initial direction, where L is a characteristic length of the system. Arbitrarily, the diameter of the sampling orifice will be equated to L. Thus

$$p = \frac{d^2 \rho U_0}{18\eta D} \tag{5}$$

It is assumed that

$$2r - D = (S - D) \,.\, f(p) \tag{5a}$$

where f(p) is an unknown function of p.

$$\text{Now} \quad K = \frac{8\pi U_0 N \int r\, dr}{\pi S^2 U_0 N} \tag{6}$$

Substituting in equation (6) the value of r, given by equation (5a), and integrating between appropriate limits for the two cases, we have:

$$\frac{C}{C_0} = K + \frac{U_0}{\bar{U}} = \frac{U_0}{\bar{U}}\left[1 + f(p)\left\{\left(\frac{\bar{U}}{U_0}\right)^{1/2} - 1\right\}^2\right] \tag{7}$$

Experimental Determination of f(p)

EXPERIMENTS were conducted in a wind tunnel of low turbulence, with a test cloud of almost spherical particles, produced by spraying up a suspension in water of two varieties of spores, lycopodium powder ($d = 32\ \mu$) and lycoperdon giganteum ($d = 4\ \mu$). Water evaporated from the droplets, to leave an aerosol consisting of near spheres of two diameters. In actual fact, evaporation of water was not quite complete at the sampling station, and there was some clumping of spores. Thus the test cloud was not uniquely definable, and the particles were on the average larger than the sizes quoted.

Samples were taken with impingers, containing distilled water. The entry tubes were of glass, each with a right-angle bend, to provide a horizontal sampling tube of circular cross-section. Different orifice diameters were used to provide different values of $U_0/\overline{U}$, U_0 and Q being kept sensibly constant for the different experiments.

The impinger liquid containing the sample was counted in a blood-counting cell. Good reproducibility of counts was obtained from a series of samples of a suspension.

In Table I are recorded the experimental conditions and the results obtained. In all runs the wind tunnel velocity was maintained at 10 mph ($\pm$ 0.5 mph) through the working section. Impinger flow rates were 10 l/ min. ($\pm$ 0.1 l/min.). One impinger ($D = 0.7$ cm.) was used as an "isokinetic" reference; others were run with values of D equal to 0.46 cm. and 1.05 cm.

Tentative Predictions from Equation (7)

FROM Equation (7) we have:

$$f(p) = \frac{\left(\dfrac{\overline{U}C}{U_0\,C_0}\right)^{1/2} - 1}{\left(\dfrac{\overline{U}}{U_0}\right)^{1/2} - 1} \qquad (8)$$

In Fig. 3 are plotted the experimentally determined values of f(p) against p. Within the limits of the original data, this curve can be used to predict C/C_0. With only a few points, the curve cannot, however, be established accurately; moreover, the values of p cannot be considered highly accurate in view, as pointed out above, of the uncertainty of the exact diameters of the test particles when they reached the sampling station. Further experiments are in hand to cover a wider range of the several variables and with a different test cloud.

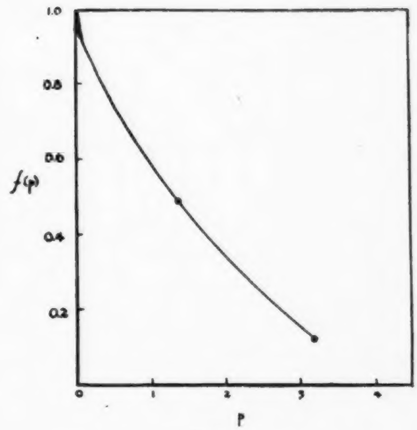


Fig. 3.
Relationship between f(p) and p.

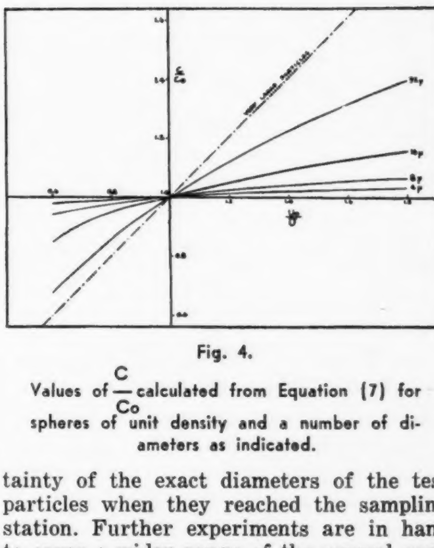


Fig. 4.
Values of $\dfrac{C}{C_0}$ calculated from Equation (7) for spheres of unit density and a number of diameters as indicated.

Fig. 4 has been derived from Fig. 3 and Equation (7) in order to give some idea of the magnitude of C/C_0 for a range of particle sizes (spheres of unit density). In making these calculations the following values have been taken:

$U_0 = 10$ mph
$Q = 10$ l/min.
D and $\overline{U}$ varied

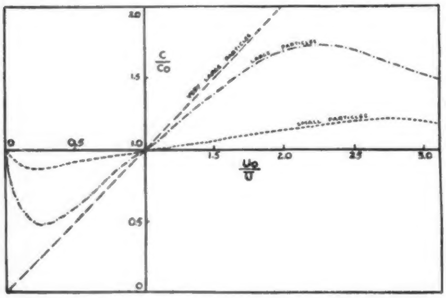


Fig. 5.

Suggested form of a relationship between $\frac{C}{C_o}$ and $\frac{U_o}{U}$ over range of $\frac{U_o}{U}$ from zero to large values.

Special Cases

It is clear that Equation (7) cannot be used to the limits when either $\bar{U}$ or U_0 tend to zero. When $\bar{U}$ is zero, we have the case of impaction on a plane circular obstacle of diameter D (or more generally, D cos θ); when U_0 is zero we are sampling from still air, when according to Davies (1947), with a small orifice, $C/C_0 = 1$. With these end conditions in mind, the shape of the curves of Fig. 4 would be expected to be of the general shape shown in Fig. 5.

TABLE I.
RESULTS OF SAMPLING SPORES OF 32 μ AND 4 μ DIAMETER

Run No.	$U_o/\bar{U}$	D(cm)	32 μ spores p	32 μ spores C/Co	4 μ spores p	4 μ spores C/Co
(A)						
6	2.25	1.05	1.39	1.49	0.022	0.97
8				1.37		1.09
9				1.66		1.08
10				1.77		1.06
			Mean	1.57		1.05
(B)						
6	0.43	0.46	3.19	0.50	0.050	0.93
8				0.49		0.99
9				0.48		0.97
10				0.50		0.95
			Mean	0.49		0.96
(C)						
2	—1.00	0.7	2.09	0.012	0.033	0.28
3				0.015		0.14
4				0.000		0.19
7				0.020		0.28
			Mean	0.014		0.22

Notes: 1. Density of spores taken as 1.04 g./cc.
2. In group (C), one impinger was placed so that the sampling orifice faced down stream (θ=180°)

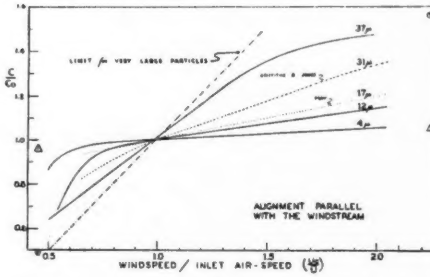


Fig. 6.
Graph prepared by Mayhood and Langstroth which includes their results and also those of May and of Griffiths and Jones. Particles sizes refer to MMD. Present spore results are also plotted ⊙ 32μ nominal dia. △ 4 μ nominal dia.

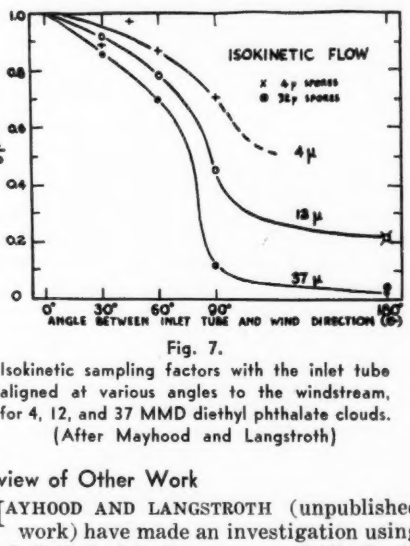


Fig. 7.
Isokinetic sampling factors with the inlet tube aligned at various angles to the windstream, for 4, 12, and 37 MMD diethyl phthalate clouds. (After Mayhood and Langstroth)

Review of Other Work

Mayhood and Langstroth (unpublished work) have made an investigation using dyed diethyl phthalate, a non volatile liquid (ρ = 1.123). Clouds, each containing a whole range of particle sizes, were produced by sprayers, and were sampled with impingers similar to those used for the work recorded above. Their results, which show some scatter, especially for values of $U_0/\bar{U}$ less than unity, are summarized in Figs. 6, 7, and 8, which are copies of graphs prepared by them. In Fig. 6 are also given results collected by Mayhood and Langstroth and obtained by Griffiths and Jones (1939-40) using coal-dust ($\rho \doteq 1.3$), and by May (1942) using clouds of dyed di-butyl

phthalate ($\rho = 1.05$). To Figs. 6 and 7 are added the experimental results with the spores.

Some Practical Considerations

A 37 μ MMD aerosol can be described as very coarse, and it normally contains particles up to at least 100 μ diameter. To obtain C/C_0 correct to within $\pm$ 10%, $U_0/\overline{U}$ must not (for $\theta = 0$) lie outside the range of about 0.86 to 1.13 (Fig. 6). Under isokinetic conditions a 10% error is obtained at $\theta = 16°$.

For a 4 μ MMD aerosol, with a maximum diameter of 10 μ (all particles of which would stand a finite chance to penetrate to the lung), the corresponding limits are about 0.5 to >2.0 and 50°.

When sampling in the open air, errors are inevitably produced because the wind is constant neither in speed nor in direction. Under a variety of daytime conditions the instantaneous speed will cover over a period of minutes a range of the mean $\pm$ 40%, and the direction will vary $\pm$ 30° from the mean. These are maximum excursions and the mean values of these deviations will, of course, be smaller.

Fig. 8 confirms the finding of Griffiths and Jones (1939-40) that low values of C/C_0 are obtained under isokinetic conditions if the value of D falls below about 0.65 cm. It is possible that the effect is partly due to the relatively large value of wall thickness. A minimum sampling orifice of 0.7 cm. is therefore indicated. Equation (7) predicts that the error under anisokinetic conditions is smaller the larger D, for a given value of $U_0/\overline{U}$. It seems desirable, therefore, for high accuracy, to sample at high volumetric rates, using large sampling orifices, to approximate to isokinetic conditions. Another advantage is that the effect of wall thickness is less pronounced. High volumetric rates are limited by the available suction, especially in the field, but it is

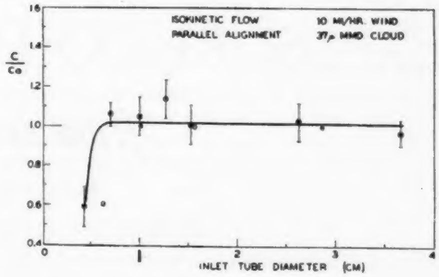


Fig. 8.
The influence of inlet tube diameter on the apparent mass concentration for ideal operating conditions. The open circles represent data obtained by Griffith and Jones for a 300 μ MMD coal dust aerosol at about 3 mi./hr. windspeed. The solid circles are data obtained in a 10 mi./hr. wind by Mayhood and Langstroth. The vertical lines through the solid points indicate the reliability of the data.

in the field that anisokinetic conditions are most frequent and pronounced. It is not considered practicable to carry a range of orifices of different sizes, nor to regulate the sampling rate according to the mean wind speed.

Acknowledgments

Appreciation is expressed by the author to J. E. MAYHOOD and DR. G. O. LANGSTROTH for the use of their unpublished results. MR. MAYHOOD suggested using spores for a test cloud. DR. G. LUCHAK suggested using an undetermined function of the parameter p in Equation (5a) rather than a definite function satisfying the necessary boundary conditions. D. F. MULFORD made the experiments leading to the results given in Table I.

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NOISE costs employers money, even if they never face a compensation claim. Medical authorities agree that—like bad ventilation and poor lighting—noise cuts human efficiency, slackens and dulls mental processes, clouds judgment, and reduces precision.
—*The Medical Advance* (National Fund for Medical Education), December, 1953.

EXPOSURE TO METHANOL

from spirit duplicating machines

R. G. McALLISTER, Industrial Hygienist
Liberty Mutual Insurance Company, Boston

AIR SAMPLES for methanol vapors, collected in a small room in which spirit duplicating machines were operated, gave high results. Because this type of duplicating machine is in common use in schools and business offices, we became interested. Doubtless many of the rooms in which the spirit duplicators are located are no larger than the room tested. Such being the case, there is good reason to believe that an appreciable number of workers are exposed to excessive methanol concentrations.

Subsequent samplings in a large, fairly well ventilated office showed much lower concentrations but still above the permissible level at the breathing zones of the operators.

Description of Equipment

THERE ARE several different makes of spirit duplicating machines commercially available but they are all essentially the same, with only minor mechanical differences, and all operate on the same general principles. The material to be re-produced is drawn, typed, or written on the master sheet which has been placed on a "carbon" paper so that the ink is transferred from the "carbon" to the back of the master sheet. The ink used in the carbon is concentrated crystal violet or mixtures of this with other dyes. The master sheet ready for the duplicating machine has the copy to be re-produced outlined in reverse in the concentrated dye. The master sheet is then placed on a rotating drum in the machine with the concentrated dye side outward.

The copy sheet is fed between two rollers. One of the rollers is kept covered with solvent (spirit fluid) fed to the roller by a felt pad from a reservoir. As the copy sheet passes between these rollers it is completely covered with solvent. The moistened copy sheet passes between another roller and the rotating drum, and as it comes in contact with the reverse image on the master sheet it will pick up a small amount of the concentrated dye and the final printed copy will be a purple re-production.

The amount of dye picked up from a master will depend on the pressure between the roller and the rotating drum, and therefore the depth of color will depend on the pressure. Since the amount of dye on the master is fixed, the number of reproductions obtainable will depend on the amount of dye removed by each copy. An average is about 300 copies per master.

Duplicating Fluid

THE SPIRIT duplicating fluids are a mixture of methanol, ethanol, and cellosolve. The methanol content of the commercially used fluids can vary from 40% to 100%. Insofar as it is known, none of the duplicating fluids are without methanol. One gallon of the fluid can do from 8,000 to 12,000 copies, with wide variations between machines and in different runs on the same machine. The methanol content of the duplicating fluid used when air samples were collected in the small test room was 70%, and 65% when later sampling was done in the large office.

Sampling Method and Method of Analysis

FRITTED-GLASS bubblers were used with distilled water as the collecting medium. The rate of air flow through the collecting device was from five to eight liters per minute.

The method of analysis was to oxidize the

Presented before a Joint Session of AIHA, New England Chapter, and A.A.A.S.

methanol to formaldehyde and test with Schiff's reagent. The results were compared to standards and read colorimetrically by eye.

Results of Sampling

DISREGARDING the ethanol and cellosolve in the duplicating fluids, samples for methanol were collected during runs of from 300 to 500 sheets on four different makes of duplicators. Breathing zone concentrations ranged from 400 to 800 PPM and general room air concentrations went as high as 1000 PPM. The high general room atmosphere concentration can be explained by the fact that the sheets of paper were moist with duplicating fluid when fed into the receiving tray of the machine and as they were handled or riffled large volumes of methanol vapor rapidly evaporated.

Leaving the door to the room open during a run decreased the methanol concentrations but they were still above the allowable limit.

Subsequent sampling at a battery of four machines, of which a maximum of three were in operation at any one time, showed methanol vapor concentrations ranging from 155 to 420 PPM in the operators' breathing zones. The machines were located in a large office with about 5000 sq. ft. of unpartitioned floor area and a 10 ft. high ceiling. General room air concentrations in the area were lower, dropping down to 65 PPM 10 ft. away from the machines.

In the Literature

INSOFAR as is known, the only report in the literature of exposure to methanol vapors from operating spirit duplicating machines is an article in the September, 1948 issue of the "Industrial Hygiene Newsletter" in which an investigation made by the Connecticut State Department of Health is reported. They found high concentrations of methanol at all machines in steady use.

In one plant about one gallon of fluid was used per day and they found from 286 to 430 PPM with an average of 367 PPM. Fluid contained 50% methanol. In a second plant only two quarts of fluid (50% methanol) was used per week and only 40 to 50 PPM with an average of 40 PPM was found. In a third plant, a consumption of fluid was 10 gallons per week (75% methanol) and they found from 510 to 635 PPM with an average of 572 PPM. They also sampled in two other plants. The article concluded, "The use of these . . . for two or three hours per day maximum, with a daily consumption of less than one pint of fluid per day, should not present a health hazard, particularly if the fluid used contains less than 50% methanol."

Toxicity of Methanol

METHYL ALCOHOL poisoning results most frequently from ingestion and the severity of the results are well known. Baskerville[1] collected, up to 1913, 720 cases of methyl alcohol poisoning, 390 of which ended fatally, 90 of which developed blindness, and 85 of which suffered impaired vision. He collected from the literature 64 cases of industrial poisonings caused by vapor inhalation, of which six ended fatally, 19 suffered permanent blindness, and 33 had impaired vision.

Maximum Allowable Concentration

THE AMERICAN STANDARDS ASSOCIATION has adopted 200 PPM as the MAC for methyl alcohol on the basis of eight hours per day exposure.

PATTY[2] reports STERNER as having found, in connection with film manufacture, methanol vapor concentrations ranging from 200 to several thousand PPM, the latter values occurring for only short periods of time. The daily average of the concentrations to which operators were exposed was probably between 400 and 500 PPM. STERNER believes these latter values would not ordinarily result in any serious effect or even moderate discomfort, since numbers of men known to him have been exposed to such conditions while handling millions of gallons of this solvent failed to show any evidence of methyl alcohol intoxication. STERNER'S experience indicates some margin of safety in the 200 PPM MAC for Methanol but, if the more susceptible individuals are to be protected the MAC should not be exceeded.

Conclusions

1. The spirit duplicators should not be used in confined areas such as small offices without exhaust ventilation. An air-conditioning system would help to dilute the solvent vapor concentrations but with steady operation of the duplicators the air supply

would be insufficient to dilute the vapors to safe levels.

2. Machines operated steadily in small rooms should be provided with an enclosing hood over the receiving basket, with an air flow sufficient to give at least 100 l.f.m. inflow through the working openings of the hood. A canopy type hood is suggested for the receiving tray, completely enclosing it except for openings to allow the paper to be fed into the tray and the finished work removed. A two and a half inch diameter exhaust duct would suffice to carry the required air flow and a small centrifugal type fan would satisfactorily move the required volume of air.

3. Intermittent operation with a total time of only two or three hours per day would need no more than good general room ventilation.

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2. PATTY, FRANK A., EDITOR: Industrial Hygiene and Toxicology, Vol. II.

Air Pollution Meeting

THE 47TH ANNUAL MEETING of the Air Pollution Control Association will be held at the Patten Hotel, Chattanooga, Tennessee, on May 3, 4, 5, and 6, 1954. The meeting will be devoted exclusively to air pollution and its control.

Some 600 management executives and other representatives of the industries, research scientists, and air pollution control officials will attend the four-day meeting. Thirty-five technical papers will be presented covering the subjects of coal, incineration, petroleum, municipal problems, dusts and fumes, steel, odors, measurements, and meteorology.

On Monday, papers will be read and discussed on Combustion of Coal, Micrometeorology, Instruments, and Gas Cleaning. These will be followed on Tuesday by discussions on Odors, Air Pollution Control Problems, Measurements and Gas Cleaning. Wednesday will be directed to Air Pollution Control Problems, Incinerators, Gas and Air Filtration, and General Papers on Atmospheric Pollution. The last day of the meeting will be set aside for plant inspection trips to study air pollution and control devices. This is the only annual Association meeting at which air pollution control equipment is exclusively exhibited.

W. C. L. HEMEON, Director of Engineering of Industrial Hygiene Foundation at Mellon Institute, is Chairman of the Program Committee. Also active in planning the meeting are: THOMAS C. WURTS, Director of the Allegheny County Bureau of Smoke Control, Pittsburgh—President of the Association; R. M. LANDON, Assistant to the General Manager of the Manufacturing Department, Gulf Oil Corporation, Pittsburgh—Co-Chairman, Annual Meetings Committee; H. P. HOBART, Gulf Oil Consultant, Pittsburgh—Co-Chairman, Annual Meetings Committee, and FAIN W. INGRAM, Director, Air Pollution Control and Boiler Inspection, Chattanooga—in charge of local arrangements.

The Air Pollution Control Association, formerly known as the Smoke Prevention Association, was founded in 1907 to fill the need for a group specifically interested in air pollution and its control.

Conference on Factory Noise

Sponsored by the Associated Industries of New York State
Schenectady, New York, October 29, 1953

THE FOLLOWING SERIES of presentations and discussions was the substance of a Factory Noise Control Conference sponsored by the Associated Industries of New York State, through its Technical Committee on Noise in Industry. More than 200 plant engineers, industrial hygienists, medical directors, personnel managers and top level executives representing some 93 industrial units participated in the session. The meeting was held October 29, 1953 at the General Electric Company Research Laboratory, located at the Knolls, Schenectady, New York.

The conference was significant for the fact that it was directly initiated by an industry association and had the concrete objective of controlling factory noise. The method for developing the subject was a series of short presentations of specific examples in which control procedures were applied. The emphasis was placed on the general principle, with the particular instance serving as a reference for broader applications.

The discussion periods were marked by the wide participation of the attendants in spite of the relatively large size of the audience. Replies to a questionnaire given to all participants after the conference attested the enthusiastic acceptance and substantial value for this program.

The Noise Problem

JAMES H. STERNER, M.D., Medical Director
Eastman Kodak Company
Rochester, New York

ALTHOUGH the concept that loud and prolonged noise can cause loss of hearing has been accepted commonly for a number of decades (for example, the persistence of the term "boilermakers' deafness"), relatively little activity in the study of the problem or in serious attempts to control noisy industrial environments has occurred until the past few years.

What then are the factors that have brought about a recognition of the "noise problem"? What is fact and what is fiction? How serious—how real, is the problem—for the workman—for the employer—for all of us?

A few months ago I did what I thought was a good job in discussing industrial noise and its effect on hearing before a group of individuals whose work was workmen's compensation insurance. At the end of the session, a question asked in all seriousness by a man who has spent a number of years in the field of compensation for industrial injuries made me realize how much of an educational job lies before us.

His question was "Is there any really good evidence that loud industrial noise causes deafness?"

For the past three or four years there has been scarcely any important meeting in industrial medicine or industrial hygiene without a symposium or a few papers on some aspect of the noise problem. The scientific journals in industrial health and safety have repeatedly carried articles on this subject—not to mention the articles in the public press and general periodicals. Yet, an individual whose job requires knowledge of the important activities in workmen's compensation is not convinced that there is a real problem associated with industrial noise and hearing loss. Apparently, with all our talking, we haven't thus far done an effective job telling the story.

In a talk such as this, it is not possible to present the evidence to support each point. But, as I discuss the essential factors in the noise problem, I shall try to give you some weighting as to their acceptance by the people who have had the greatest experience and are the recognized experts in the field.

Industrial noise is on the increase, paralleling the expansion of our industrialization. Not only are more people now involved than

ever before, but the machines of industry are creating louder and louder noises. Sooner or later, even without the stimulus of a Slawinski case (or, we might add, a Wojcik case, as in Wisconsin), we would have been forced to turn our attention to the hazard of industrial noise. The decision of the New York Court of Appeals in 1948 admittedly precipitated interest and activity which has now spread far beyond the borders of the Empire State. I should like to review, briefly, this important event.

In 1948, the action of the Court of Appeals sustained an award for loss of hearing from repeated and continued exposure to industrial noise, even though there was no associated lost time from work and no loss of earnings. The fact that the Workmen's Compensation Board recognized the administrative difficulties due to the complexity and uncertainties inherent in the problem, tended to confine the area of action, but only a decision—reversible at any time—requiring a six months' waiting period before final adjudication, has held back a flood of claims which could be ruinous to many industries. The hazard of noise is real, not only to the thousands of workmen exposed, but to the very operations which give them their livelihood.

Factors of the Hazard

LET US BRIEFLY examine the essential items: Noise can and does cause deafness. Further, we can elaborate, noise at certain high levels of intensity presently existing in industry produces severe changes in the internal ear which, though reversible in the early stages, often lead, on continued exposure, to permanent injury and consequent partial deafness. Although there is considerable disagreement as to the actual levels and the duration factor, I have not encountered a single responsible investigator in the field who questioned the truth of this statement.

Immediately, upon acceptance of this axiom, the question is asked: "How much noise, of what quality, and of what duration, will result in hearing loss?" Many people have guessed, a few have dignified their estimates with limited supporting data, and a considerable number now are laboriously developing the variety and weight of evidence that will be needed to establish reliable and accurate criteria. The most recent, and apparently the most thorough, approach to the job has been done by the American Standards Association Committee which has just made a preliminary report. Many of you are familiar with that work. For the present, however, we have only the considered, but limited, estimates of intensity, frequency, and duration to guide us.

The measurement of noise can be done effectively and reasonably with equipment now readily available. This does not mean, however, that an adequate evaluation of a particular noise situation can be done by an unskilled technician with a simple sound level meter. With good equipment selected for the particular situation, microphones, sound level meters, frequency analyzers, and so forth, the trained analyst can accurately characterize the noisy environment, in terms such as frequency, intensity, duration and intermittency, or steady status. Even with our presently limited standards, this information can be of value in determining the degree of hazard and in guiding our control efforts.

The determination of the hearing status of an individual can be reasonably well achieved in terms of pure tone audiometry. Again, the equipment is readily available, but the value of the test is in direct proportion to the training and skill of the operator and to the interpretive intelligence of the otologist. Several methods are in use for translating the results of pure-tone audiometry into terms of disability, but there are major defects in all of them. Currently, representatives from the professional otological societies are working on a better procedure, but the results of their labors have not been announced.

The variability of the testing procedures, and of the operators, make the testing of the hearing of an individual a less reliable performance than the measurement of the environmental factor—noise, but the major difficulty lies not in the physical test but in the determination of the disability.

The fact that hearing loss, indistinguishable, by any present means, from that which results from exposure to high noise levels, occurs in the general population in individuals who have not had an exposure to loud noise, is a serious complication. It is recognized that the frequency and severity of such deafness increases with each decade

of adult life. How shall this factor, then, be equitably introduced into the compensation problem? Admittedly, we can average the value, but an inequity will result if we pay on the basis of an average, giving an award that is undeserved to some individuals and, on the other hand, penalizing others whose hearing loss may actually have been solely due to the industrial exposure.

Another important, but still unsolved factor, is that of the reversible components of hearing loss. Good evidence suggests that six months or longer away from the noisy environment is required before a satisfactory base line of non-reversible hearing loss is obtained in some individuals. In the case of an individual still at work, even though the principle of a scheduled award where there is no loss of earnings is continued, a true evaluation of disability can not be obtained.

These are only a few examples of the many aspects of the problem which must be solved before a fair and equitable conclusion is possible. Admitting these facts—that industrial noise injures hearing, and that both the noise and the hearing loss can be measured (although at present, not accurately related)—what is the importance of the problem to New York State industry?

We have no good estimate of the number of people working at operations with noise levels in the range suggested as injurious. Nor have we accurate information as to the number of claims already filed. In one community alone, however, it is known that the claims have exceeded a million dollars. The discrepancy between the serious apprehension of those individuals who have closely followed developments in this area, contrasts markedly with the apathy of many employers who already have a real, though unrecognized, problem.

In addition to the compensation aspects, as reliable criteria relating noise to hearing loss are developed, industry will be faced with the problem of conforming to safe practice as required in Safety Codes established by the Department of Labor.

Even though industry weathers the storm of a large number of claims for which there are no accrued insurance reserves, as it did in the instance of silicosis, it must learn to control the hazard to avoid continuing ruinous compensation costs.

The discussion thus far has been limited to economic aspects and to the technical factors in evaluating the problem. There are, in addition, broad sociologic implications. If noise could not be controlled, one might well balance the value of some hearing loss against the opportunity for earning a living. But it has not been proved that the control of noise is impossible or even technically impractical or economically unsound. Until every reasonable effort has been made to control the hazard, one has good reason to question a situation in which an individual may be deprived of a function so valuable as the ability to hear, even though it does not lessen his ability to earn.

In closing, we must mention two other potential effects of noise, although they are not important in our consideration today. The first is the interference with communication. Although this is difficult to evaluate in terms of job efficiency, work output, and job satisfaction, in the opinion of many competent investigators in this field, interference with communication ranks second in importance to that of the definitely deafening effect of noise.

Another area, the emotional, psychological and public health effects of noise are very controversial in character. Although they can in part be demonstrated under certain laboratory conditions, it is unlikely that they are of primary importance in actual industrial circumstances.

Summary

THIS, THEN, is the problem: Industrial noise can, and under certain circumstances does, cause deafness. Here in New York the compensation situation with respect to occupational hearing loss is critical, with only an administrative ruling damming a flood of claims, a flood which, because there are no accrued insurance reserves, could mean disaster to many of our industrial units.

We have most of the tools needed to evaluate the problem. We need desperately to have much more information relating hearing loss to noise in terms of intensity, frequency, duration. We need to know all of the other significant factors in hearing loss, the non-occupational elements, the relation between the reversible and irreversible components. We need an accurate, fair, and

equitable method for translating hearing loss into disability and ultimately into compensation.

But do not be deluded that with the development of this information our problem will be solved. The accumulating evidence emphasizes that the noise hazard is real, that deafness does occur, and that even though it were possible for industry to bear the burden of severe compensation penalties, an increasing social consciousness will not accept indemnification as a solution.

The otologist, the physicist, the industrial hygienist, or the industrial physician can define the problem, but the only basic and really satisfactory solution—the control of noise—requires the cooperation and effort of the engineer. If we can get industry to recognize the importance and magnitude of the problem, we can find the means to prevent further disability, and by providing one more element toward a safe and healthful industrial environment, add appreciably to our effectiveness and our common good.

Noise Can Be Controlled

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CAN YOU REMEMBER back to the earliest automobiles, to the early airplanes, refrigerators, vacuum cleaners? There is no comparison between the rattle, clank or roar of these early scientific wonders and their quieter modern-day counterparts. Even the street car and subway train have succumbed to progress. These changes have been brought about as a direct result of consumer demand. Once the incentive was there, the accomplishment was merely a matter of time.

The first question frequently asked when we approach an industrial noise problem is, "How are you going to control *this* noise?" The implication being that no matter what our successes may have been in the past we are now faced with the impossible. This may then be followed by a complete recitation of all of the reasons why this noise cannot be controlled. This negative approach almost inevitably means that the noise won't be controlled. Conversely, good results have nearly always been obtained where a positive attitude existed.

Many production people are concerned with the possible high cost of noise reduction, or with possible interference with production. Some are suspicious of the fact that no pat answers are available, that it is frequently difficult to predict results. All of these are valid reasons for taking a long look at any noise control proposal, but they must not provide the excuse for not trying anything.

There are several essential factors in any approach to noise reduction:

The Will To Do the Job—A half-hearted approach will be no more successful in the acoustic field than in facing any production problem. If you embark on a noise reduction program with the conviction that it cannot succeed, it probably will not.

An Open Mind—Many successful solutions have been quite unorthodox. It may be possible to reduce or even eliminate noise by a change in method. Even though an operation may have been carried on in the same way for generations, there may be a quieter —and perhaps even better—way of doing the job. We are working in a field where we have little precedence. Noise control at this stage is truly a test of ingenuity.

Proper Analysis of the Problem—Successful noise control must be based on a proper evaluation of the problem. The noise must be analyzed and studies made of both the noise sources themselves and the environment including the building and the effects of surrounding equipment. Once the source of trouble has been studied in detail and delineated, the amount of reduction required can be determined on the basis of whether noise is to be controlled because of potential damage to hearing, because of annoyance, or to solve a communication problem. With these facts established it is then possible to take the necessary engineering steps to accomplish the desired results.

Basic Approaches

WITH OUR PRESENT state of knowledge, it is impossible at this time to set forth simple basic principles which will govern all possible situations. We are in that development stage where each problem pre-

sents different aspects, many of which require special treatment. There is a wide variety of kinds of noises, for example, including impact types from drop hammers and presses, chipping, pneumatic hammers, tumbling barrels, firing ammunition. There is a wide variety of problems related to the flow of air or gas through nozzles as in the case of air ejection of small parts from presses, fuel supplies to furnaces, the wide usage of air in industry. We also have friction problems related to moving parts in machinery and grinding and sanding operations. There are siren-like effects resulting from the operation of saws and various types of high speed cutters, wood working planers and similar types of equipment. There is also a problem of vibration produced in machines, as well as in metal parts, which are being worked. These are but a few of the variations in kinds of noise sources which we encounter industrially. There is no question but that each of you could add many more to this list.

On machines it is desirable to make noise flow diagrams tracing the noise from the original source, through its transmission paths in the machine to those parts which are radiating the noise to the air. This will indicate possible ways in which the noise source can be modified or isolated; lines of transmission broken, or sound radiators isolated or modified. In cases where such treatment is not possible, some type of acoustical enclosure may help.

In addition, the influence of the environment must also be considered. The type of building construction, location of noisy equipment, nature of ceiling and wall surfaces, and influence of other equipment, are important factors.

The results of these evaluations will then dictate the kinds of treatment which will be required to accomplish the desired results.

Control Measures

IT IS POSSIBLE in the brief time available to mention just a few of the kinds of things which can be done to reduce noise in industrial plants. You will hear before the end of this session, examples not only of these approaches but also of others which have proved successful in combatting noise exposures.

Changes in Process—In certain instances this approach may provide almost an unlimited number of opportunities to eliminate completely a noisy process. It is also possible that such changes may even increase production or improve the quality of the product. This, however, should be considered a dividend, and not the basic criterion for making a change. Conversely, such changes will not be acceptable if they appreciably reduce production or adversely affect the quality of the product. Such an approach generally requires a considerable amount of patience in dealing with production people and a considerable amount of vision in deciding on the change. Here are a few examples of the kinds of changes which are possible:

(1) Use of electric tools in place of excessively noisy pneumatic ones.

(2) Pressing in place of forging.

(3) Grinding instead of chipping.

(4) Modification of materials handling methods—using equipment such as resilient conveyors, instead of metal conveyors, and avoiding the dropping of metal parts into metal tote boxes.

(5) Mechanical ejection from presses instead of air ejection.

Acoustical Isolation—This is a means of providing an acoustic barrier between noise sources and groups of employees. In the case of a few noisy machines in a large department it may be possible, by physically isolating the offending equipment, to reduce substantially the number of people exposed. The individual machines can then be handled as separate problems. Such isolation has been attempted on the basis of complete physical separation and also by the use of acoustic panels between machines. It is possible to go a step farther in some instances and completely enclose individual noisy equipment with acoustic barriers. During the course of the discussion to follow you will hear examples of both of these methods.

Modification of Existing Equipment—Techniques have been developed for tracing the path of noise energy through machinery. It may be possible as the result of such an analysis to find means of interrupting the transmission of noise energy from the source through the machine to a resonating part of the machine. There are many ways

of providing such interruption which may greatly reduce the airborne noise from such equipment. In addition to this it may also be possible to isolate the noise source from the rest of the machine. Another approach is to provide some sort of modification of surfaces which are radiating the noise from the machine to the surrounding air. This technique is one which offers great promise in handling noise problems from some existing types of equipment.

Control of Air and Gas Jets and Exhaust Silencing—A vast amount of compressed air is wasted in industry as a result of its uncontrolled use for air ejection, cleaning of parts, and the like. This same wasteful process also contributes considerable high frequency noise in many industrial plants. The use of reduced air pressures and more carefully designed nozzles holds promise for solving both of these problems simultaneously. All too frequently we see a piece of copper tubing connected to a 100-pound pressure line squeezed with a pair of pliers to a narrow opening used as a means of ejecting finished parts from presses. There is no question but that the job could be done with considerably less air and certainly with considerably less noise if reducing valves and properly designed nozzles were used for this purpose. A similar problem exists in the case of nozzles for high pressure fuel lines. A little more thought in the original design of these nozzles without question will reduce considerably the amount of noise produced from this source.

In many types of pneumatic equipment, air is exhausted directly to the atmosphere with the production of a considerable amount of noise. It has been found that ordinary commercially available silencers when placed on such exhausts can eliminate this as a noise problem.

Maintenance—A considerable amount of noise from aged equipment is a direct result of lack of maintenance. A carefully set up and supervised program of lubrication, replacement of worn parts and tightening machines can get rid of a lot of extraneous noise. Since it is a well-known fact that noise in industrial machinery is a sure sign of wear, this alone should provide the incentive for establishing such a program.

Use of Resilient Materials—There are many kinds of equipment such as chutes, tumbling barrels, conveyors and tote boxes being used in industrial plants today which are made of sheet metal. We frequently see metal parts being dumped into these metal containers or equipment. The use of resilient materials such as rubber on conveyors and liners for tumblers and liners for tote boxes will in many cases provide ample noise reduction.

Vibration Mounting—As you know vibration mounting of equipment is extremely important in the use of heavy machinery to prevent transmission of vibration to building structures and even to prevent transmission to surrounding buildings. One should be extremely cautious, however, about the use of vibration mounting as a method of noise control. We have had one incident in which we have studied comparable drop hammers and found slightly higher air-borne noise levels from hammers which were well mounted. Thus, while vibration mounting is essential for this type of equipment, it must not necessarily be considered as a means of air-borne noise control.

Design for the Future—The ultimate and long-range answer to our problems can come only from careful consideration of the noise problem in the design of new machinery. While this will not solve our present dilemma, we must get started soon if our burden is to be lightened in the future. Examples of this type of approach are the new type loom developed by a leading manufacturer which is revolutionary in design and reported to be amazingly quiet in contrast to current weaving equipment and a fairly recent development in forging equipment which holds great promise as an ultimate solution to this problem. An automatic forging unit has been built, and is now in experimental use in several plants, which is reported not only to be considerably quieter than conventional forging equipment but also to have many production advantages over such hammers. If this change can be accomplished successfully and have widespread application in the forging industry it seems to me that nothing is impossible in the way of noise control.

Drop Hammers

THE QUESTION of how to control the noise from drop hammers has frequently been raised. It must be borne in mind in facing

this problem that there is a large variety of types and sizes of hammers and at least two ways of operating them. Different approaches will be necessary under different conditions.

There has been at least one attempt made to reduce the noise from this source by means of a partial acoustical enclosure. Such an enclosure must be as close to the hammer as practical and have minimum opening.

In the case mentioned above a sliding acoustical door which closed just ahead of the impact and opened as the hammer rose was provided. This type of enclosure gave substantial reduction in noise but introduced production problems when the operation was entirely manual. This approach might prove satisfactory if tried on a hammer in which the stock is placed and removed mechanically.

Modification of the hammer itself will also provide some reduction. Acoustical isolation of such parts as the ram and anvil cap from the frame by means of a resilient material may help.

The purpose of this kind of treatment is to reduce transmission of vibration through the frame. This should be undertaken only after detailed study of the hammer. Consideration must be given to heat, weight and the hammer rating in selecting the resilient material.

Approaches of this sort will provide some relief from hammer noise. These are indications of ways in which the problem can be approached. There are undoubtedly others, but solutions can come only from actually trying such things.

Conclusion

WHILE this discussion has attempted to point the way to many approaches to the control of industrial noise, I would like to stress that the application of these principles in many instances is not simple. The important message I would like to convey is that while the solutions to many of these riddles may appear on the surface to be next to impossible to achieve, there are many possible approaches open to us. We will never know until we try how successful we can be in solving any particular problem. Industrial noise not only can be, but is being, controlled.

Noise Control Demonstration

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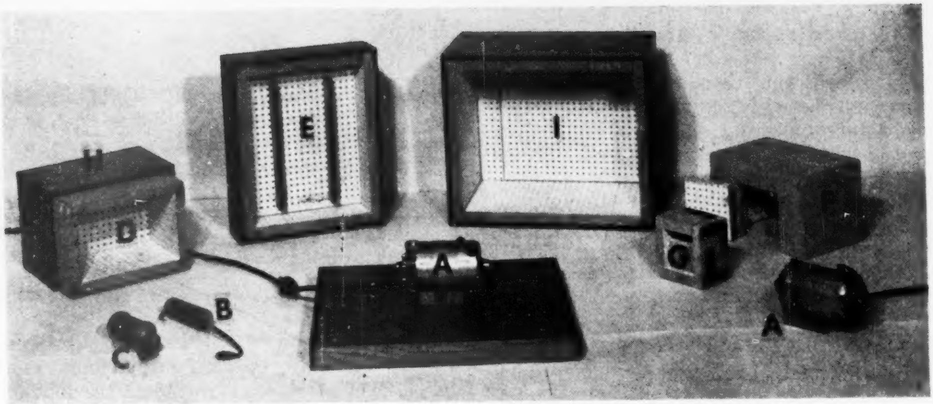
NOISE REDUCTION obtainable through the use of enclosures was the subject of a number of questions presented to the General Motors Industrial Hygiene Department by personnel of operating divisions. The model demonstration pictured on the following pages was designed to show the general order of reduction obtained through the use of mufflers and simple enclosures as well as showing some of the pitfalls which should be avoided. The actual demonstration has been made at a number of meetings in General Motors plants in addition to the presentation before the Associated Industries of New York State, Inc. This demonstration has proved more effective in getting the noise reduction story across to plant personnel than technical papers, reports and graphs. The various components entering into the demonstration are shown in the largest of the accompanying photographs, identified by letters from A to I.

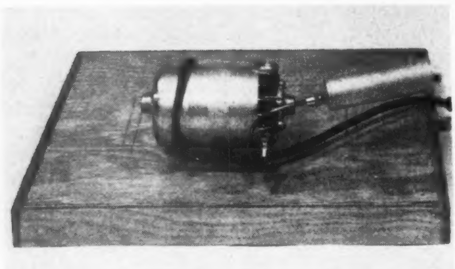
The demonstration includes a noise source in the form of a Dumore air pump familiar to industrial hygienists. Two pumps are used throughout, one remaining as a reference noise, while the other is either muffled or enclosed in the course of the demonstration. Octave band analysis of the noise from the pump at approximately two feet distance is shown on the accompanying graphs.

The mufflers used consist of an "Atomuffler" made by the Allied Witan Company, Cleveland, Ohio, at the intake or top side of the pump and an exhaust muffler described in "Equipment for Collection of Contaminants" by Harris *et al*, *Archives of Industrial Hygiene and Occupational Medicine*, 7:6, 501 (June) 1953.

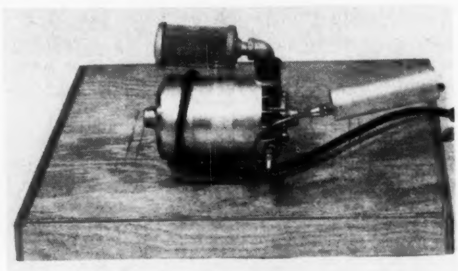
The base shown in the photographs is 14½"x17"x1½" and consists of a layer of ¾" Acousti-Celotex Cane Fibre Tile (N.R.C.—0.65) sandwiched between two layers of ⅜" plywood. It was made merely to serve as a uniform mount for the demonstration. The small box, H, is made of ⅜" plywood, 10"x7½"x6½" outside dimensions.



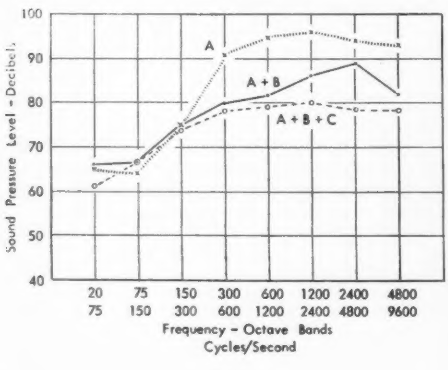
Components used in demonstration



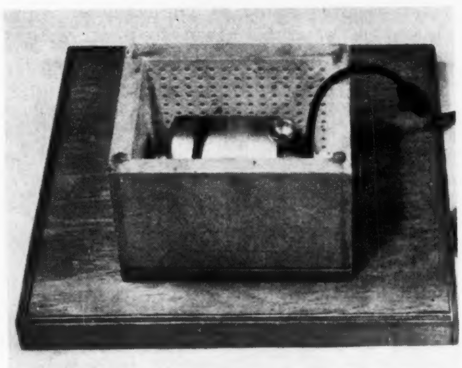
A and B



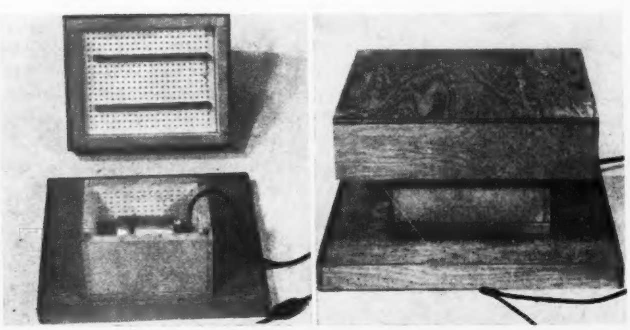
A, B, and C



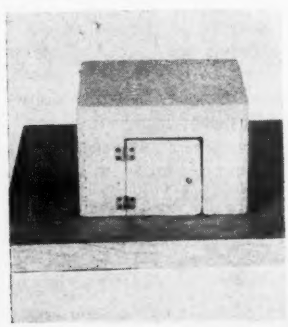
Graph I



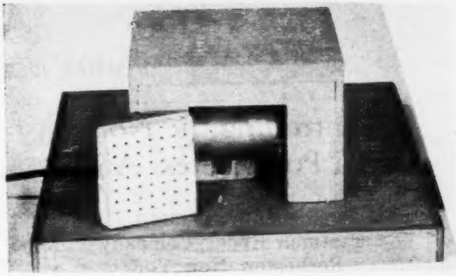
A and D (open top)



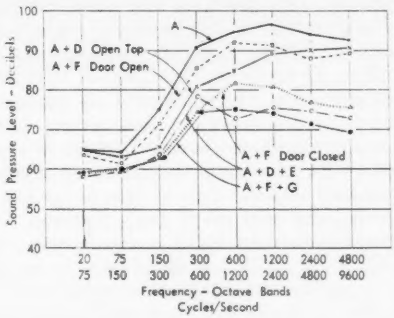
A, D, and E (open and closed)



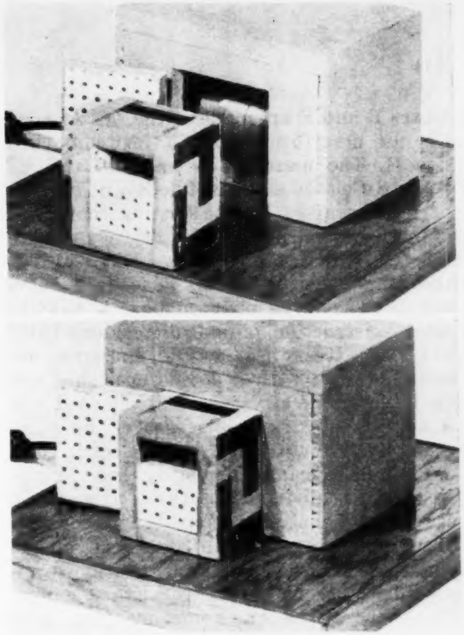
A and F (door closed)



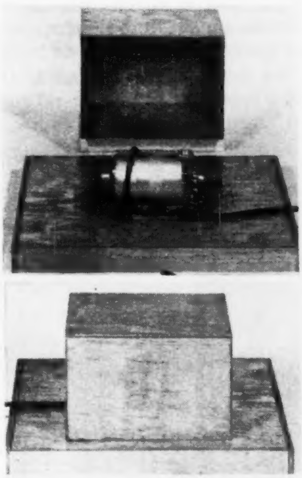
A and F (door open)



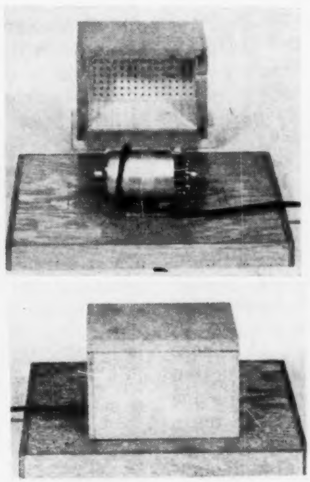
Graph 2



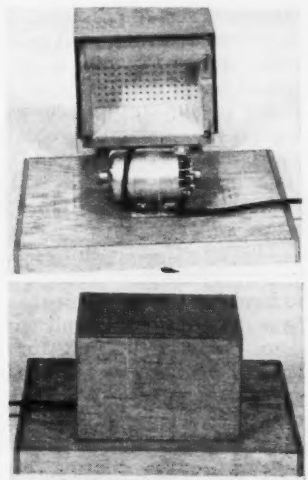
A, F, and G (open and closed)



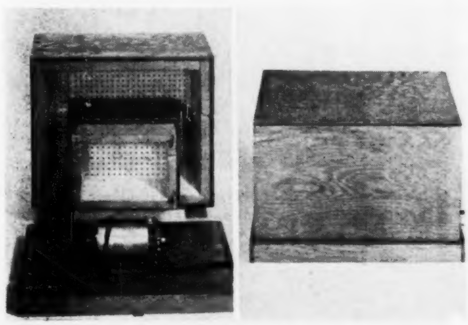
A and H



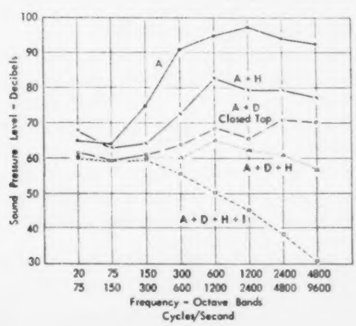
A and D



A, D, and H



A, D, H, and I



Graph 3

Boxes D and F are made of the ¾" Acousti-Celotex described, and will just slide into box H. The maze, G, is made of the ¾" Acousti-Celotex and will friction fit into the open doorway of F. The floating roof, E, is of ⅜" plywood lined with the ¾" Acousti-Celotex, outside dimensions 15"x12"x4". In the demonstration it was spaced 1" above box D. The large plywood box, I, has the same construction, outside dimensions 16½" x14"x10". It is provided to illustrate results obtained with a double enclosure and an intervening air space. All plywood and Acousti-Celotex boxes placed over the pump are notched for passage of the electric cord.

The photographs depicting the demonstration are divided into three groups. An octave band analysis was made for each condition illustrated. In all cases the microphone of the level meter was positioned approximately two feet from the source. Where more than one component was used to reduce the noise, photographs illustrating the exploded construction as well as the enclosure used are presented. Curves showing the original octave band analysis and the results obtained by the control method illustrated follow each group of pictures.

The demonstration shows that for this pump the reduction obtainable through mufflers is only 14 db. and that considerable high frequency noise is still emitted. Noise radiation from the pump body is probably responsible for this.

The effect of openings in enclosures is amply illustrated. The effect of cracks around loosely fitting doors can be inferred by comparing the result given for box F, door closed, with that for box D. These boxes have the same size and construction except for the loosely fitting door. The noise reduction obtainable with a labyrinth maze at an opening, to allow for a personnel passageway or ventilating air, are demonstrated to be appreciable. The addition of a floating roof over an open top enclosure results in considerable reduction.

The lined plywood enclosures yielded the greatest reduction obtained in this model demonstration. Lining a plywood enclosure yielded a 16 db. reduction as compared with the unlined enclosure. The lined double enclosure with intervening air space yielded a 36 db. reduction showing the improvement possible with such interrupted construction.

Controlling the Noise from Punch Press Areas

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ONE OF THE COMMON and quite satisfactory methods of controlling noise is the complete enclosure of the noise-producing machine. In applying this method it is very important that the enclosure be complete.

In one area where a number of semi-automatic punch presses were stamping out small parts, the complete enclosure method was tried. Around one of the presses was built an enclosure of ⅜-inch plywood. The enclosure also included a roof over the punch press. The inside of the enclosure was completely lined with sound-absorbing tile. Fig. 1 shows a picture of the enclosed press with the access door open. The sound-absorbing tile was placed on the inside of the enclosure to absorb the noise produced. It is much more effective on the inside than it would be on the outside. On the inside it has the effect of absorbing the noise rather

Fig. 1.
Enclosure around semi-automatic punch press.

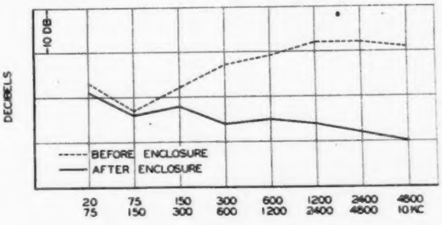

Fig. 2.
Noise reduction by enclosure shown in Fig. 1.

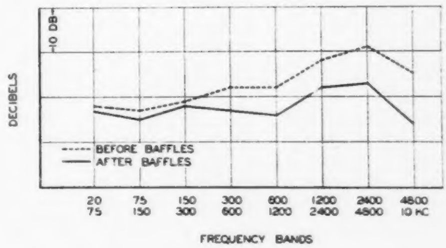

Fig. 3.
Noise reduction by use of acoustical baffles.

than allowing it to bound off the walls and thus greatly increase the noise level inside the enclosure. Small openings which are necessary for the transfer of the raw material to the press and for the transfer of the finished parts from the press have to be specially treated, otherwise they are likely to be noise leaks.

The noise reduction obtained with this enclosure (Fig. 2) was greatest in the high frequency end of the audible spectrum, where the noise is most annoying. An overall reduction of 12 db. was obtained, but in the range above 1,000 cycles the reduction was from 15 to 21 db.

This type of enclosure will give about the same db. reduction no matter what level of original noise is present. This will be true provided the background level is low relative to the level of the reduced noise.

On another punch press a partial enclosure was tried. In this case, the enclosure was around only the die area, with a window so that the operation of the die could be observed. The sides were made of Transite. The transmission loss of Transite is about the same as plate glass. Again the sound-absorbing tile was placed on the inner faces of this enclosure. There was no treatment of the slot through which the finished parts were removed from the press.

The noise reduction in this case was slight. A 2 db. overall reduction was obtained, with a 5 to 6 db. reduction in the two high frequency bands.

In attempting to enclose a large press it was found that the motor and driving mechanisms extended some distance on one side. The enclosure as originally built left an opening so that the motor was readily available for servicing. The reduction obtained with this enclosure was again small, being about 2 db. When this open side was rebuilt and completely enclosed, making the enclosure much larger, the overall reduction obtained was increased to 9 db. The reduction in the high frequency ranges was proportionately greater as it was in the previous cases.

These last two examples show the importance of the proper design and the complete enclosure of the noise-producing machine that are required to obtain effective noise reduction. It also emphasizes the importance of noise leaks and the necessity of specially treating the required openings. It is quite often difficult to do a satisfactory job of sound reduction on a piece of machinery by enclosing it and at the same time be able to use the equipment. This often calls for considerable engineering ingenuity in design and arrangement.

Where it is not possible to enclose the noise-producing machine, some noise reduction can often be obtained by hanging sound-absorbing bats or baffles in the noisy area. These bats are made of sound-absorbing material such as Fibreglas, commonly 8 to 12 sq. ft. in area and varying in thickness from one to three inches. In use, these bats are hung from the ceiling in the noisy area and serve to absorb both direct and reflected noise which strikes them. It is desirable to have them as low as possible. This method is similar to covering of the wall; but in many cases, is much more effective since both sides of the bats are exposed for noise absorption. Also, the sound-absorbing material can often be closer to the source of the noise.

In one punch press area, approximately 50 of these bats were hung. The overall sound levels were reduced from 3 to 9 db. depending on location. With this method of

noise control, the greatest reduction is normally at a distance from the noise-producing machines because they serve to absorb sound normally reflected to the working area. However, a real reduction is obtained in the immediate area. Treatment of this type is particularly satisfactory where there are a number of people working in the same general area.

The curves in Fig. 3 show the noise reduction obtained by hanging sound-absorbing bats. The greatest reduction in any single frequency band was 11 db. which was obtained in the 4800 to 9600 cycle band.

Although this method was not expected to be as effective as complete enclosure, it has proved more successful than some partial enclosures. It is felt that this method may be, in many cases, a partial solution to industrial noise problems.

In employing noise-reduction methods, either by enclosing the equipment or hanging baffles, it is important to consider the fire hazard. Where possible, all of the sound-absorbing materials should be non-combustible.

Noise Reduction by Enclosing Jordan Shredding Machines

HAROLD W. CROUCH

THE PROCESS in paper making which uses Jordans (a type of pulp shredding machine) produces a rather disagreeable noise due to the fact that a large part of the noise is in the high frequency part of the audible range. After reviewing the problem, it was decided that the only practical solution was to enclose the machines. Absorbing this noise, or enclosing the Jordans, seemed quite a problem since everything around a paper mill is likely to be wet, and there is often water leaking out of the machine itself. This precluded the possibility of using the common fibre-type of sound-absorbing materials.

To enclose the Jordan, a hood was built of 14-guage sheet metal. It was lined with a three-inch blanket of flexible Fibreglas. This blanket was held in place by corrugated perforated aluminum. The hood was made so that it could be placed over the Jordan. It was of such size and weight that three or four men could easily lift it off for servicing purposes.

As was expected, this type of enclosure did not give the sound reduction usually obtained with some of the good types of sound-absorbing materials. However, an average reduction of 7 db. was realized in the Jordan area by placing these hoods over the machines. This is an example of noise reduction which was accomplished under rather adverse conditions, but it does indicate that in many cases worthwhile results can be obtained.

As a further reduction of the noise from this area, it is planned to line the walls in the immediate area with sound-absorbing tile.

Enclosure for a Can Divider

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A CAN DIVIDER is a device for splitting a conveyor line of cans into two lines. Fig. 1 shows such a divider. Cans fall into the top, bounce on a bar at the bottom of the divider and roll off randomly in either direction. This particular divider is placed in a freight car to feed the cans to both ends of the car simultaneously. Because of the lack of sound absorption in a freight car this device produces a fairly high noise level even at the ends of the car.

Discussion

RE-DESIGN of the divider, making use of a power operated switch in the conveyor line and elimination of the necessity of dropping the cans, would be the best long-term solution to this problem. However, if we are required to use the present dividers in the meantime, the most practical alternative is a partial enclosure of the noise source.

The enclosure cannot completely surround the noise source since three rather sizeable openings must be left for the cans. It is impossible to add an acoustically lined duct to these openings since it must be possible to remove cans from the tracks adjacent to the divider.

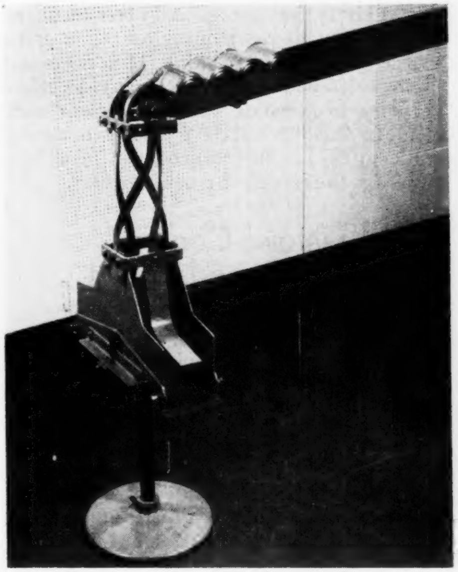

Fig. 1.
Splitting a conveyor line of cans into two lines.

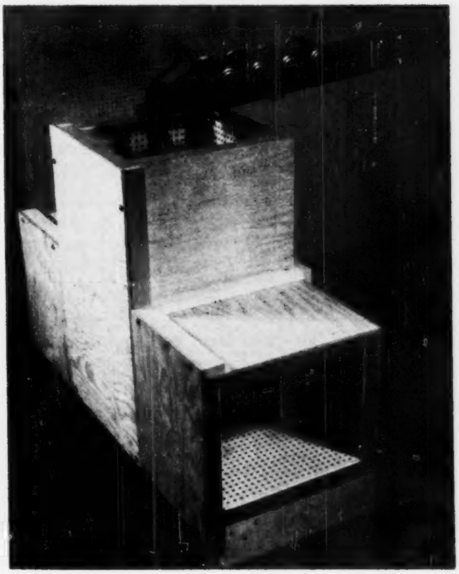

Fig. 2.
Can divider with acoustical enclosure.

Noise Control

PRELIMINARY measurements showed that the sound pressure was radiated in all directions in a fairly uniform fashion from the bar at the bottom of the divider. The radiating area was reduced from the area of sphere to the area of three small portions of that sphere. This was accomplished by enclosing the divider with a solid housing and lining the inside with absorbing material to prevent reverberant build-up. The remaining open area was about 1/10 of the original radiating area. Therefore, the total radiated acoustic power should be reduced about 10 db., by the area change, but the reverberant build-up within the enclosure will tend to counteract this reduction. The exact amount of this build-up will depend on the amount and absorption of the acoustical lining of the enclosure.

The enclosure described here (see Fig. 2) was a trial model constructed in a rather rudimentary fashion. For this reason plywood lined with acoustic tile was used.

Measurements

OCTAVE BAND noise measurements were made at a number of locations around the divider both before and after enclosure. Fig. 3 shows some of these measurements. Those made prior to enclosure were all roughly the same; however, those made afterward were quite different. Note that the measurements made at the top opening and near the lower openings were considerably greater than those made at the side of the enclosure.

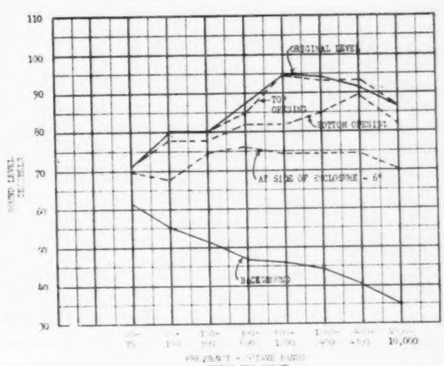

Fig. 3.
Measurements of the noise from the can divider under various conditions.

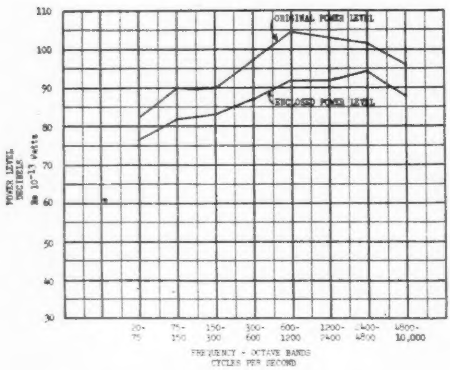

Fig. 4.
Effect on the power level produced by enclosing the can divider.

This emphasizes that the over-all evaluation of a noise control treatment cannot be made by before and after measurements at a single point. The total acoustic power being radiated should be found. The change in this quantity is really the measure of the effectiveness of a treatment, since it predicts the level in the reverberant field. In particular, note that a before and after measurement made at the top opening gives an entirely different evaluation of the enclosure than a similar measurement made at the side.

The acoustic power level for the before and after conditions is shown in Fig. 4. This was computed from data similar to and including those shown in Fig. 3. The reduction in power level is slightly greater than expected, but this may be caused by the fact that the full area of the openings is not radiating noise whenever a can passes through. The slightly smaller reduction at lower and higher frequencies was predicted with good accuracy by the decrease in the absorption coefficient of the acoustic tile at these frequencies.

Conclusion

THE NOISE reduction gained by enclosing the can divider was enough to bring the noise in the freight car to an acceptable level. Any greater noise reduction would have been pointless because the enclosed divider is no longer the most important noise source in the car.

An important lesson to be gained from this study is that before and after measurements at a single point close to a noise source are often misleading. It is necessary to make measurements at many locations in order to compute the total power radiated. In this way it is possible to predict the change in the reverberant level produced by the modified noise source.

Noise Control for a Strand Cutter

JEROME R. COX, JR., SC.D.

CONTINUOUS STRANDS of plastic about 1/8" in diameter are cut up into pellets by means of a rotary cutter. This cutter is not unlike a lawn mower. The several blades shear off the strands against a light metal plate. Each time a blade strikes a strand an air-borne impact noise is radiated to the surroundings. Also, vibration is transmitted to the frame and to the rest of the machine. In addition, an impulse travels up the strands which produces noise at points quite remote from the cutter. This noise is caused by the strands slapping against the rollers which feed them to the cutter.

Discussion

THE ABOVE description of the sources of noise is only qualitative. It can be obtained by a little careful listening and, perhaps, a few measurements. This qualitative picture is often all that is necessary, however, in order to start on the problem. An initial effort can be made to quiet all sources of noise. If a particular noise source or transmission path stubbornly resists quieting or presents difficult engineering problems, it can be studied with greater success if some of the more obvious noise control steps have already been taken.

Noise Control

THE PEAK levels produced by an impact noise depend upon the peak force transferred. The impulse transferred can be kept the same, but the peak force reduced by stretching the blow over a longer time. Thus a reduction in the rotational velocity of the cutter should reduce the peak noise level. In order to handle the same volume of material, the number of blades must be in-

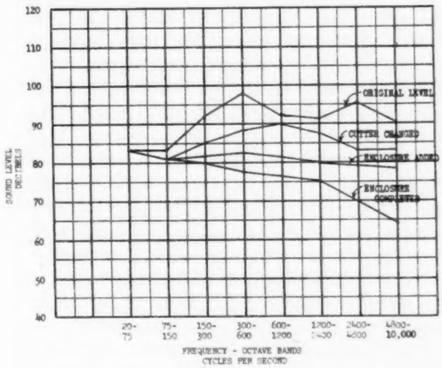

Fig. 1.
Effects of successive modification and enclosure of strand cutting machine.

creased proportionally. Therefore, the cutter speed was halved and the number of blades doubled. The plate against which the strands are sheared was increased in thickness to decrease the force transmitted to the rest of the machine. In addition, the whole cutter assembly was mounted on rather stiff vibration isolating material.

The effects of these changes are shown in Fig. 1. The top curve was the original level in a reverberant room. This level was practically independent of the directional characteristic of the source. Therefore, the reverberant level is dependent upon the total acoustic power radiated and not upon the pressure radiated in a particular direction. When the changes to the cutter assembly outlined above were accomplished, the reverberant level was that shown in the curve second from the top.

As a second step the entire cutter was enclosed with a metal cover. The inside of the cover was lined with glass wool to reduce the reverberant build-up of sound inside the enclosure. It was necessary to leave an opening in the enclosure at the entrance to the cutter. The reverberant noise level for this modification is shown in the curve third from the top. Note that the noise reduction was disappointingly small. The enclosure did not do its job because of the noise that escaped through the opening at the cutter entrance. Some noise was still being radiated from the vibrating strands. An extension of the enclosure that closes off the opening and covers the strands as they approach the cutter yields the additional noise reduction shown by the bottom curve in Fig. 1.

Conclusion

THE SOLUTION of this noise control problem is intended to show that a step-by-step approach is often successful. In this case, the first changes produced a reduction in level that significantly reduced the hazard to hearing. If this were all that were necessary, no further steps would be taken. The next step produced an additional reduction which made communication possible by shouting or by a very loud voice at mouth-to-ear range. The final changes made it possible to converse in a loud voice at a distance of a foot. Therefore, the noise control necessary depends on the results desired. Cut and try methods are useful when the job is of a magnitude too small to justify the large expenditures of expert engineering time necessary to design noise control that will do the job on the first try. Finally, the example highlights the importance of careful measurements, particularly octave band measurements. Without them the results of the various steps would have been incomprehensible. Measurements with the sound level meter alone leave many questions unanswered. In fact, it would have been impossible to recognize the improvement produced by the final step without octave band analysis of the noise.

Reducing Noise of Glass Grinding

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IN THE MANUFACTURE of photographic plates a beveling operation on the glass is necessary to eliminate the sharp edges. This process is known as "seaming." The operation consists of moving the glass plates between two rows of grinding wheels which do the beveling. This produces a considerable volume of noise, especially in the high frequency end of the spectrum.

It was found that most of the noise was produced by the vibration of the glass itself as it was being ground. In an attempt to reduce this vibration, a stationary tray

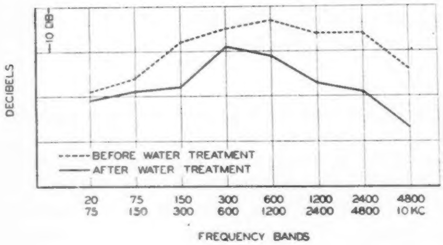

Fig. 1.
Noise reduction obtained by damping with water.

was placed under the glass and filled with water. This was close enough to the glass so that one surface of the glass was in contact with the water. This reduced the vibration of the glass sufficiently so that a considerable reduction in noise was obtained as shown in Fig. 1. An overall sound level reduction of 7 db. was obtained at the operator's ear level, with a maximum reduction of 13 db. in the two high frequency bands. It was found that the contact between one surface of the glass and the water was important. When there were a number of air bubbles trapped at the glass surface, this technique of reducing noise was considerably less effective.

Personal Protection

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WHENEVER we have noise levels that affect human health, safety or efficiency, we try to control the noise. This noise control can be accomplished principally by three methods. The first and best method eliminates the noise completely at the source. That is, the source is so designed that it does not generate noise. Many times machines can be designed in this way or changed accordingly. The second noise control method attenuates the sound (reduces the energy of the sound wave) on its way to man. In this case the attenuation is accomplished quite close to the source. The third method of noise control is to attenuate the sound at the receiver (man). In this case an attenuating device is placed over the human ear. This third method of noise control should be used only when all other methods fail or are not economically feasible. Unfortunately this situation is often found.

Faced with the problem of noise levels exceeding human tolerance limits, first of all we should attempt to eliminate the sound (prevent its initial production). If this cannot be done, we should attempt to attenuate the sound in the immediate vicinity of the source. If, after application of these two methods, the noise level in the work space still is too high for human safety, personal protective devices must be provided for men exposed to noise.

An important question now arises. That is: When is a dangerous noise level reached? The question is very hard to answer because the determination of the effect of the noise on man's ears involves consideration of at least three major factors. The first factor is the noise intensity. The second factor is the frequency characteristic of the noise and the third factor is the duration of man's exposure to the noise. The noise level that the human ear can tolerate may vary considerably, depending on the variations of these three factors. It is relatively easy to state harmful levels for short exposure times. We can be sure that an instantaneous exposure to a sound level of 150-160 db. is harmful because, in this range, the ear drum is broken and the middle ear bones are pushed out of position. This level is certainly dangerous.

The sound levels producing other effects are not so well defined. Certainly, when the sound level is about 140 db. we feel definite acute pain in the ear. However, we are not able to relate this pain directly to any specific damage. If we are exposed to the noise for some time, damage to the inner ear will occur but if the exposure is short, a minute or so, nearly everyone can tolerate a sound level of 140 db. without any noticeable permanent damage. Therefore, the threshold for pain as well as the threshholds for other sensations, such as discomfort or speech interference, are not good indicators of impairment. In these cases impairment is always influenced by the length of time the human ear is exposed to a given noise level.

THE ONLY OTHER damage criteria that we have are proposed criteria pertaining to lifetime exposure to the noise. Recently several groups have attempted to establish criteria for damage to the human ear caused by noise exposures of these durations. But the problem is so complex and our knowledge is still so limited that the American Standards Association's Exploratory Committee agreed that a standard could not yet be stated. On the other hand some starting point is essential immediately for the engineering design of practical noise control structures and as a guide to emphasize and request the need for personal protection. For this reason the U.S. Air Force has adopted tentative damage risk criteria until more accurate standards can be stated. These criteria wlil be used in the following discussion although they are not necessarily recommended for use by other organizations. The concept behind these criteria is that when people work in certain noise levels day after day, eight hours a day for several months or years they certainly develop some hearing loss. The curve specifying the noise levels that will produce such hearing loss is naturally only a probability curve. Therefore, a noise level a few decibels higher or lower than the specified level may not have a markedly different effect. On the other hand, it appears quite certain that noise levels 10 db. below the so-called "deafness risk" or "damage risk" criteria will certainly not cause hearing loss even when people are exposed for very long periods of time. Likewise, noise levels 10 db. or so above these criteria have high probability of inducing hearing loss.

A damage risk curve for wide band noise which the U.S. Air Force is now using for the solution of practical problems is shown in Fig. 1. The sound pressure levels per octave band are approximately 95 db. for all bands above 300 cps. In the lower frequency range the ear can stand slightly higher levels, up to approximately 110 db. in the lowest frequency band. For pure tones the sound level that can be tolerated is about 10 db. lower as is indicated by the curve in Fig. 1 labelled "pure tones and critical bands of noise." The noise levels prescribed by these curves may look quite low. The 95 db. level per octave is actually

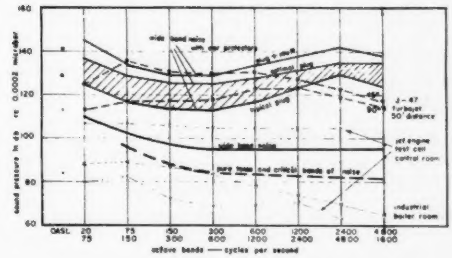

Fig. 1.
Damage risk criteria for steady noise and for lifetime exposures. The criteria are given for the protected and unprotected ear. Several industrial noise spectra are given for comparison.

not a very intense noise, and I desire to emphasize once again that these curves apply to lifetime exposure conditions and that they represent the best approximation available today as to noise levels that can be tolerated by the human ear. We are now ready to state that, wherever noise levels exceed those specified by these damage risk criteria, persons working in these environments should wear some form of ear protection.

EAR PROTECTORS have deficiencies. They do not give infinite attenuation. On the average, ear plugs provide a maximum attenuation of 30-35 db. The question now is, why do they not provide more attenuation? Usually in designing attenuating structures it is possible by adding more mass and more attenuating material to obtain any desired amount of attenuation. The attenuation attained is limited only by the cost and the massiveness of the structure.

In the case of personal protective devices, the acoustic leak which establishes the limit of their effectiveness is through the human body itself. Our failure to obtain adequate protection by these devices is not of our own making, but is a consequence of human body structure. If an unprotected human being is exposed to a sound field the largest percentage of acoustic energy per unit of surface area is absorbed by the auditory canal. This energy falls upon the ear drum and most of it reaches the inner ear. The part of the total sound energy reaching the inner ear through this pathway is called "air conducted sound."

We can think now about an ideal ear

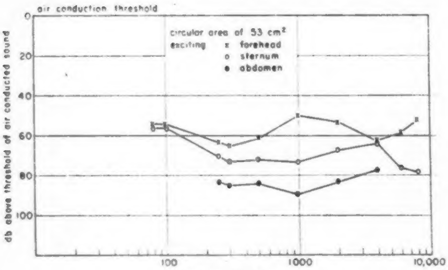

Fig. 2.
Threshold of hearing for sound received by different areas of the body relative to the air conduction threshold.

plug, that is, one which would close the auditory canal so completely that no sound entered the ear by this path. Nevertheless, some sound still would reach the inner ear. However, the level of the sound reaching the inner ear now is about 50 db. below the level of that which would be found with the ear canal open. This sound is conducted to the inner ear through the skull. It is called bone conducted sound. It is, therefore, obvious that no matter what we do to the ear canal (we can have 100 db. of attenuation in the ear canal) this attenuation will be by-passed by the bone conduction pathway through the skull. The upper curve of Fig. 2 shows how much the sound conducted through the bones of the skull is reduced below that conducted through the normal "air pathway." The levels shown in this curve lie 50-60 db. below those for the air conduction pathway. This sound transferred through bone, determines the maximum achievable protection when using an ear plug.

The next, apparently logical, proposal is to cover the man's entire head with a helmet which shuts out some of the sound and thus reduces bone conduction. We have tested experimentally protection achieved in this way. This was done by applying the sound to the breast bone only. The results are shown in Fig. 2 in the curve labelled "Sternum." We see that in the higher frequency range we obtain about 10 db. of protection but in the low frequency range (below 600 cycles) there is no significant reduction of the sound reaching the inner ear below that which reaches it when the sound is applied to the bones of the head. Thus, so long as the chest cavity is exposed, a helmet over the skull will only provide 10 db. or less of additional protection.

If now we cover the entire human chest and allow the sound to fall upon the abdominal wall we find a further reduction of approximately 10 db. in the sound transmitted to the inner ear. Thus the reduction in sound reaching the inner ear is really not significant when we protect either the entire head or the head plus the chest wall because so long as the sound falls on any part of the abdominal wall relatively large amounts are transmitted to the inner ear by conduction through the tissues. Thus if we must obtain greater protection than can be provided by closing off the ear canal (ear plugs or ear plugs plus muffs) the only practical procedure is to enclose the entire body in a sound excluding box or chamber.

FIG. 3 is an equivalent circuit to show the complicated systems involved when we attempt to provide protective devices for man's ears. The figure can be analyzed to show the conditions when (1) a man wears

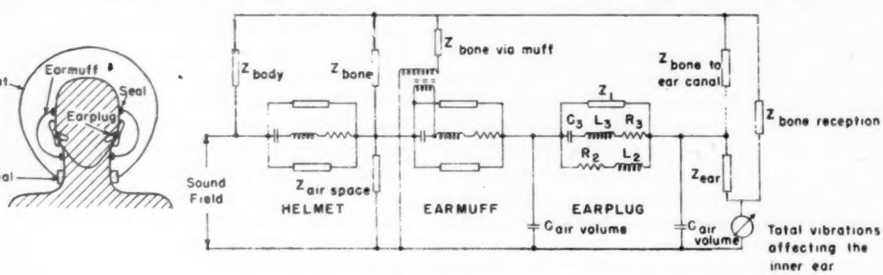

Fig. 3.
Sound protection devices on the human head (equivalent circuit.)

ear plugs, (2) he wears ear plugs plus muffs and (3) he wears ear plugs, muffs and a helmet around the whole head. In all three cases there are three possible pathways around the protective devices for the sound. These systems will not be discussed in detail and we shall concern ourselves here only with a brief discussion of the case where a man wears ear plugs. In this case, the first possibility is that the sound passes through the ear plug itself, that is, the sound is carried through the ear plug material. In this case some of the sound will go through path one (ear plug) of the equivalent circuit shown in Fig. 3. This is always a small part of the total sound reaching the head and the outer end of the plug. The second pathway is for the sound to pass to the inner ear through either a designed leak or an involuntary leak around the ear plug. That is, the ear plug is not occluding the canal tightly and sound leaks through to the ear drum. However, when using a good ear plug and when care is taken to obtain a good seal we can nearly completely eliminate this pathway also. There is still a third way in which the sound can reach the inner ear. That is, the ear plug vibrates as a unit rigid mass in the elasticity of the skin lining the ear canal. These vibrations of the ear plug as a rigid body are responsible for the limits on the protection that can be provided by an ear plug. As you can see little can be done to improve this condition. Therefore, most ear plugs, when no leaks are present, attenuate the sound up to the limit which is determined by the skin elasticity.

We have measured the constants of the skin elasticity and also the skin damping. Using these constants we calculated the attenuation curve that one would expect from an ideal ear plug. That is, from an ear plug which is completely solid; where no sound passes through it. These facts are illustrated in Fig. 4. We observe that for the low frequencies we obtain an attenuation of approximately 28 db. and that from 100 cycles upward we obtain more attenuation. Therefore, no matter what we do, we can never expect to have an ear plug that gives us more than about 28 db. of attenuation at the low frequencies.

For the higher frequencies, as Fig. 4 shows, the attenuation increases and could

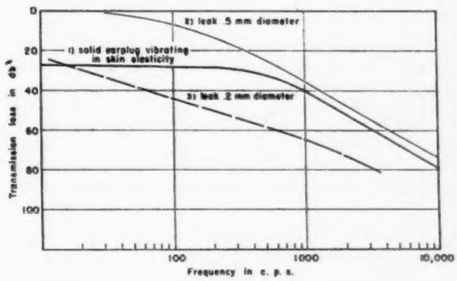

Fig. 4.
Calculated curves for sound transmission through ear plugs and leaks (curve 1 for V-51R ear plug).

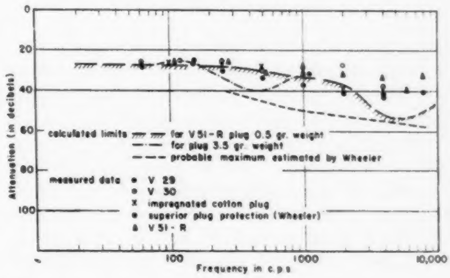

Fig. 5.
Practical and theoretical limits for protection by ear plugs.

be as great as 80 db. However, these high values cannot be obtained in practice because the sound which is transmitted by the bones of the skull is only about 50 db. below that which is transmitted through the open ear canal. Therefore, the protection afforded at higher frequencies by the ideal plug is by-passed by the sound conducted through the skull bones. These results are shown in Fig. 5 by the curve labelled "Calculated Limits." As you can see you may expect an attenuation curve which starts at about 28 db. for the low frequencies and which at the high frequencies provides the attenuation as shown (somewhat more than 45 db.); because protection limits of the plug at the higher frequencies are determined by bone conducted sound. This figure then shows (the shaded curve) the theoretical curve for the maximum protection we can obtain under optimal conditions, extrapolated from two facts, (1) at the low frequencies the limit is established by the skin elasticity and (2) at the high fre-

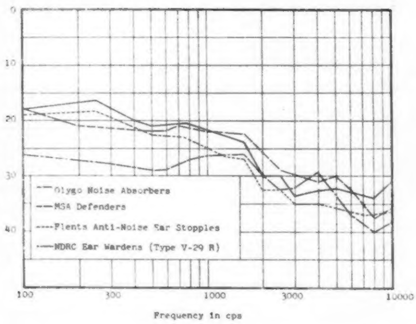

Fig. 6.
Attenuation provided by various types of ear protectors (insert type).

quencies it is established by the bone conducted sound. On this figure and in Fig. 6 we have also plotted the attenuations actually measured on several ear plugs.

Plastic and rubber ear plugs, V-29 and V-30, impregnated cotton ear plugs and the V-51R ear plug are represented in Fig. 5. In this figure it is not the average protection that is plotted. It is the maximum observed protection. Therefore, as you can see the maximum observed protection approximates closely the maximum theoretical sound attenuation to be expected from an ear plug. This indicates that there is very little more which can be done to improve the ear plug itself. Actually the only remaining action that could be taken is to insure that we always obtain the maximum attenuation. If there is only a small leak in the ear plug then at low frequencies the attenuation is much less than this value. Under these circumstances we obtain only 5 db. to perhaps 10 db. of protection. The "dashed-dot" curve in Fig. 5 represents a theoretical ear plug having a mass of 3.5 grams, which corresponds filling the whole ear plug with lead. We see that even in this case there is no appreciable improvement of the maximum attenuation obtained. In Fig. 6 the average attenuation values are shown for several types of ear plugs worn by a large number of people. It must be emphasized that these are average values, not maximum values as shown in the previous figure. Observe that these average values are lower than the maximum values shown in Fig. 5. Also observe in this set of curves that the values of attenuation for the best protector are very close to those stated by our theoretical predictions but that on the whole the average values for attenuation are lower than the predicted values. Summarizing these findings we can state that it makes little difference which ear plug we use, so long as the ear plug fits tightly and has no leak. There are, however, differences with respect to comfort among the ear plugs but this factor will be discussed later.

LET US NOW examine the use of ear muffs. If we cover the entire ear with shields, so-called ear muffs or donut type protectors, then we should be able, theoretically, to reduce the sound to the limit established by bone conduction. Unfortunately, up to the present time no one has been able to obtain this much attenuation. The attenuation has been limited in this case by the difficulties of fitting the shields to the skin of the rather irregular area which surrounds the human ear. Thus, it is very hard to obtain a good seal, that is, an air tight seal which still has sufficient mass to attenuate the sound on its passage through the sealing material. The significance of these factors are shown in Fig. 7. The lower curve of this figure shows the theoretical limit for attenuation that is established by the bone conducted sound. When practical ear muffs are worn, fitted so that the applied pressure is not too uncomfortable, the attenuation obtained is shown by the solid curve of this figure. When the pressure of application is increased until the muffs are quite uncomfortable the seal is improved and the attenuation as shown by the middle curve in the figure is obtained. Work is under way to improve this situation and to

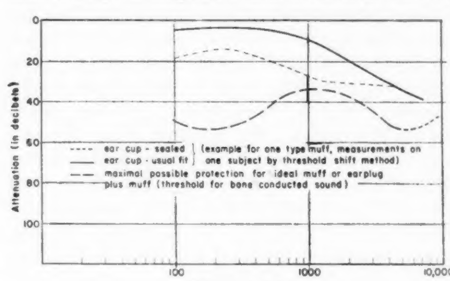

Fig. 7.
Practical and theoretical limits for protection by ear muffs.

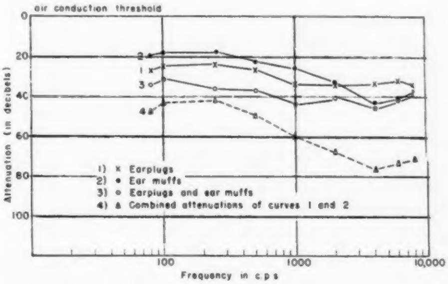

Fig. 8.
Subjective attenuation of ear plugs, ear muffs and a combination of plug plus muff measured by the threshold shift method. (Curve 1 through 3 are measured, curve 4 is calculated).

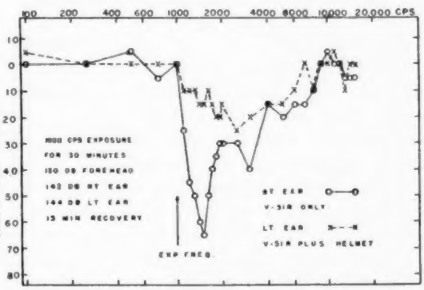

Fig. 9.
Temporary hearing loss after exposure to a 1000 cps tone of 150 db. sound pressure level for 30 minutes. Right ear protected by V-51R ear plug, left ear protected by plug plus ear muff in combination. Audiogram taken after 15 minutes recovery time.

obtain better protection at low frequencies. At present, however, it appears safe to say that there is no product on the market that gives much more protection than shown by these curves for practical muffs (Fig. 7) and no device approximates the theoretical maximum protection.

If we wear both ear plugs and ear muffs we would expect the attenuation provided by these two devices to add up so that they provide protection up to the limit established by bone conducted sound. Unfortunately we observe for most ear plug plus muff combinations somewhat lower values. In Fig. 8 we show a curve measured when wearing ear muffs alone. A second curve shows the measured attenuation for ear plugs alone. The third curve showing greatest attenuation is obtained when we wear both ear plugs and ear muffs. This third curve shows that we obtain attenuation values at high frequencies which are close to the limits set by bone conducted sound. At low frequencies we do not obtain quite as much attenuation. The values shown were obtained with uncomfortably high pressures on the muffs. No muff can be expected to perform as well under practical conditions because it would be too uncomfortable.

It might appear that we gain very little by applying ear plugs and ear muffs in combination because the difference in attenuation provided is only about 5 or 6 db. However, Fig. 9 shows the protection achieved. This figure shows data for one subject who wore a rubber ear plug (V-51R) in the right ear and on the left ear he used this ear plug plus an ear muff for which I have given the attenuation curves. This figure shows the temporary hearing loss measured 15 minutes after a 30-minute exposure to a sound field of 150 db. The sound pressure levels outside the protected ears were 142 db. in the right ear and 144 db. in the left ear. These data demonstrate the remarkable difference between the hearing loss produced in the doubly protected ear and in the ear protected only with the V-51R ear plug. It is strikingly evident that the combination of protective devices affords much greater protection than one device alone.

THUS FAR we have discussed more or less theoretical aspects of ear protection. That is, we have discussed maximum possible protection that might be achieved and have also discussed the protection that has been achieved with practical ear plugs. However, these are not the main problems that confront us today with respect to protecting the ear from the noise. That is, the major problems are not the establishment of theoretical limits for plugs or the limits set by bone conduction. The primary problem is to insure that people actually wear the protection. This problem must be attacked mainly through an educational program. You must assign this task to a person with sufficient experience, education and enthusiasm so that he can tell exposed personnel why they must wear ear plugs. He must explain the danger from the noise exposure and make it clear that those ex-

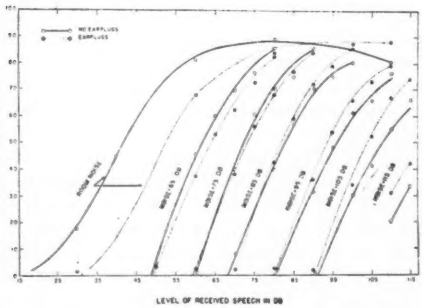

Fig. 10.
The relation between the percentage word articulation and the speech level with and without ear plugs. The parameter is the level of the masking noise. V-51R ear plugs were used. The data show an improved intelligibility in the presence of intense noise.

posed do not notice the slowly developing damage to the ear. A film is now in preparation by the armed services to be used in informing their personnel about (1) the danger of the noise, (2) the protection which is provided by ear plugs, (3) the importance of choosing the right size and (4) the methods for the proper care and handling of the ear plugs so that they will always provide their best possible protection.

Experience has shown that personnel usually look upon ear plugs with something less than enthusiasm. That is, they obtain the plugs and after about five minutes they forget them, and do not wear them. Often the unfavorable judgment is made within the first few minutes after personnel receive the ear protectors. It is, therefore, important to show them immediately that an ear plug has noise reducing action. This can usually be accomplished by taking them into the noise where they are exposed both with and without the ear plug. In doing this it is of major importance to insure that the personnel are fitted with a plug of the right size and that is properly fitted so that it will attenuate the sound to the maximum possible extent. If this is not done and if, at the very beginning, they use ear plugs which do not fit they are convinced that the plugs afford no protection and they will not wear them.

It is usually unwise to select a single type of ear plug, saying this is the best plug, and attempt to use it to fit all personnel. It is usually far better to select several types of effective ear plugs and allow personnel to choose the types which are most comfortable for their ears. This is desirable because there are striking differences in sizes and shapes of human ear canals. These differences in ear canal sizes and shapes are so pronounced that in spite of the fact that most manufacturers provide ear plugs in several different sizes it is probably not possible to fit more than 90% with any single commercially available type of ear plug. In some cases it is necessary to use a pliable type of ear plug or a wax impregnated cotton ear plug which can be molded and fitted to any shape of ear canal.

One objection to ear plugs raised by many workmen is that they may not be able to understand necessary conversation when they wear the plugs. That is, they believe that speech intelligibility is made worse when using the plugs. This belief is actually untrue. It has been shown by careful experiments that in high noise levels speech intelligibility is better when ear plugs are worn. At first this may appear to be astonishing, but when you think about the fact that the signal to noise ratio stays the same when you wear ear plugs and that by wearing them you keep the total signal and noise level lower, then you realize, that the distortion introduced by high level signals is removed by wearing the plug (reducing the signal) and the speech signal is understood better at the lower level. It is therefore very important to make personnel understand that communication in noise levels of approximately 90 db. and above is better when they wear ear plugs. At first most people think this is odd. It is easy by practical demonstration to convince them of the truth of these facts. For instance most pilots are convinced after one short demonstration that they understand speech better with ear plugs when they wear the plugs under their headsets which is the source of the speech signal for their communications. Fig. 10 demonstrates the fact that at lower noise levels the intelligibility of speech in noise is better without plugs. But it also shows that as the noise level increases the speech intelligibility with ear plugs improves, and when a noise level of approxi-

mately 85 db. is present, intelligibility is about equal with and without the ear plug. At noise levels of 90 or 95 db. and above the intelligibility of speech is better while wearing ear plugs.

A program designed toward conservation of hearing is essential. This program should be under the supervision of an adequately trained and experienced person. It is desirable to have the ears examined medically before ear plugs are fitted since there is always a possibility that the canal is filled with hardened wax or that in some cases the ear canal itself is specially sensitive to materials of which ear plugs are made. In the case of wax filled canals the wax should be removed. Sometimes in the case of sensitive ear canals it is not advisable to use ear plugs.

In cases like those just mentioned it is necessary to use ear muffs as protectors. These do not give as much protection but in many cases protection will be sufficient. On some jobs workmen are exposed to oil or other dirt so that these materials on their hands make it quite difficult for them to use ear plugs which must be inserted and removed from the ear from time to time. This is especially true for the malleable (wax-impregnated) type insert defenders. Under such circumstances, it is also advisable to use ear muffs even though they give somewhat less protection.

It is imperative that personnel be properly instructed in the care and cleaning of ear plugs. Most plugs can be cleaned with soap and water and it must be ascertained that there is no dirt or old, hardened wax on the plug at the time they are inserted in the ear canal.

IN SUMMARY it can be stated that an ear plug under most circumstances, provides adequate protection from sound levels up to approximately 130 or 135 db. In this case the exposure is considered to be continuous over a long period of time. If the exposures are very short, sound levels about 20 db. higher can probably be tolerated. But the exposures should be avoided if possible and in any case the exposure times should be kept to a minimum. In Fig. 1 the noise spectra in two different jet engine test-cell control-rooms are shown. The higher one is definitely above the level established by the deafness risk criteria and in this case ear plugs must be worn. The noise in the other control room is below the levels established by the deafness risk criteria and under these circumstances it is safe to work without ear plugs. If we add to the deafness risk criteria the attenuation obtained using ear plugs we can establish a new deafness risk criterion applicable to the case where a typical ear plug with an average seal is worn. This new criterion curve is shown in Fig. 1 and is marked "Typical Plug." On the other hand when we have an ear plug that is exceptionally well fitted so that a superior seal is obtained we obtain a still better curve which in the figure is labelled as "Optimal Plug." If, in addition to the ear plug, we use over the plugged ear a noise excluding muff, then we obtain still better protection as shown by the curve marked "Plug plus Muff." The several curves just described are, in fact, the deafness risk criteria which are applicable when the various types of protection described are worn. In the same figure, for comparison, the noise level generated by the J-47 turbo-jet engine at a distance of fifty feet is given for two different angular positions with respect to the engine centerline. These angles are 45° and 90°. Comparison of the noise level at the 90° position with the deafness risk criteria as increased by the use of suitable protective devices shows that at this position one may work in safety while wearing ear plugs. However, when we consider the 45° position we see that the noise levels are such that the protection afforded by the protective devices (ear plugs) is not sufficient to permit personnel to work with safety in this location. Since in the case of the example cited, personnel must work close (at even shorter distances than illustrated in the figure) to these power plants, everyone is seeking a solution to the problem. The most desirable solution is *reduction of the noise at the source* and a great deal of effort is being expended to decrease the noise output of these engines. As demonstrated in this figure, when the noise levels produced by the source reach approximately 130 db. there is no satisfactory solution for the problem of protecting continuously exposed personnel except to reduce the noise at the source. Fortunately in most industrial noise situations the intensities are not

as high as those shown, but stay usually in the work areas in the range below 120 db. In this range personal protective equipment, properly used, can provide sufficient protection to insure that exposed personnel will not develop permanent decrease in hearing sensitivity.

Substitute Equipment

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THE POSSIBILITY of developing a new and quieter tool or changing the method of doing a particular job more efficiently and quietly presents many opportunities for noise reduction. Two such tools are shown in Figs. 1 and 2. Both of these tools successfully eliminate the need for high velocity impact of metal against metal by the substitution of slow acting pressure and shearing action. Fig. 1 shows how this tool is used to straighten the raw edges of a welded flange around the windshield opening of a car body. The operation was originally done by the use of a backing plate and an air hammer. A reduction of 18 db. was accomplished by the substitution. The shearing tool shown in Fig. 2 is a successful substitute for an air chisel formerly used to cut handling tabs of metal from the windshield and rear window opening of car bodies. A reduction of 8 db. was attained with the shear.

Fig. 1.
Squeeze tool for straightening pinch weld flange.

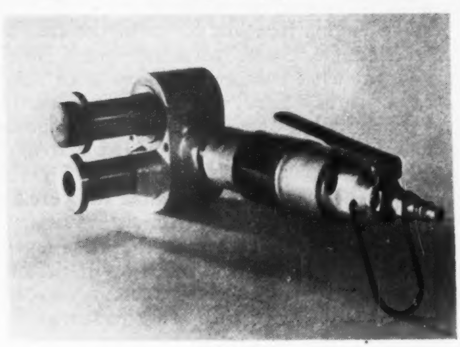

Fig. 2.
Rotary tab cutting shear.

The use of rubber-tired rolling stock instead of steel wheels for factory trucks and trailers can also be cited as a worthwhile substitution. In one series of controlled tests a reduction of 8 db. was attained by using rubber-tired wheels.

Liners

H. W. GUTEKUNST

THE APPLICATION of a resilient lining material for barrel tumblers is an effective method of noise reduction. Fig. 1 shows a ½" neoprene lining as applied to a small barrel tumbler. Attenuation on this particular installation is not known, but the improvement reduced the noise level below the

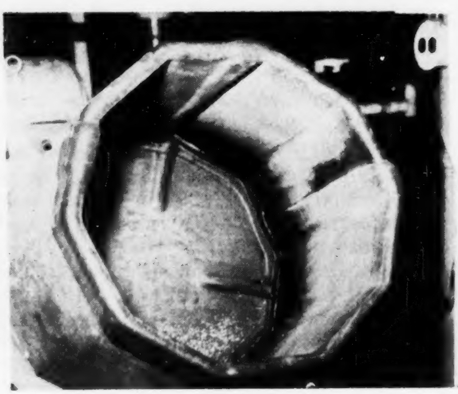

Fig. 1.
Lined barrel tumbler (neoprene).

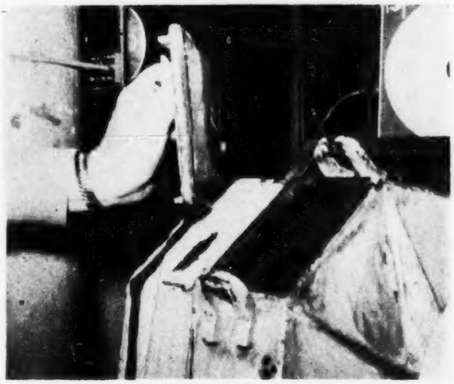

Fig. 2.
Small barrel tumbler (plastic liner).

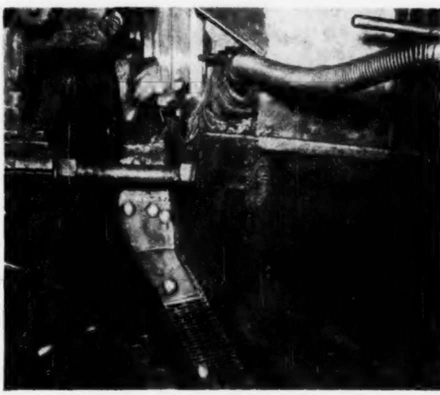

Fig. 3.
Coil spring ball chute.

background of the area. Noise generated by barrel tumblers varies greatly depending upon size and type of barrel, kind of stock being tumbled, speed of tumbler, and type of abrasive used. Worn and poorly maintained tumbling equipment can contribute greatly to the noise created by such machines. Fig. 2 shows a smaller tumbler lined with a sprayed-on lining of plastic. The effectiveness of this material is not known, but it is possible to apply this lining to tumblers not otherwise capable of being fitted with a portable lining. Production-wise, liners have the advantage of prolonging the life of the tumblers by protecting the walls from denting and abrading.

Fig. 3 shows a partial liner of rubber in a chute on a ball grinder. While the liner does reduce the noise to some extent, its life is very limited in this particular type of service. In the upper right hand part of the illustration can be seen a loosely coiled spring which is used to return the stock back to the machine. Attenuations on these two types of control are not known as they have been in service only a short time.

Mufflers

H. W. Gutekunst

Several divisions of General Motors have developed mufflers to reduce the noise level created by the release of compressed air.

Fig. 1 shows a small muffler, used to silence the exhaust from solenoid valves of

Fig. 1.
Compressed air muffler.

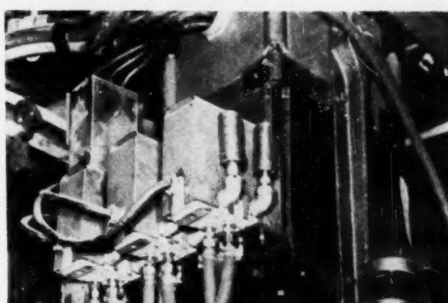

Fig. 2.
Air exhaust mufflers installed on welding fixture.

spot welding equipment. Fig. 2 illustrates equipment with two mufflers.

In one group of welding machines where 1400 of these mufflers were installed, a reduction of 6 db. was attained. The use of this muffler is not confined to spot welding machines, but can be applied to any air exhaust where the capacity of the muffler is not exceeded.

Another division has applied the muffler shown in Fig. 3 to heavier equipment using large air volumes. These are essentially the same as mufflers used on trucks and passenger cars. Another development of this same division is illustrated in Fig. 4 and 5. The arrow in Fig. 4 points to a central discharge air valve for five spot welding machines. The noise from this source was controlled by enclosure shown in Fig. 5. The construction of this rectangular enclosure consists of wire mesh and fiber glass covered with sheet steel. With this device an attenuation of about 35 db. can be attained.

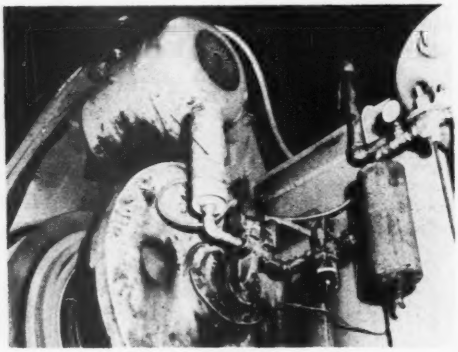

Fig. 3.
Truck muffler applied to air valve on large press.

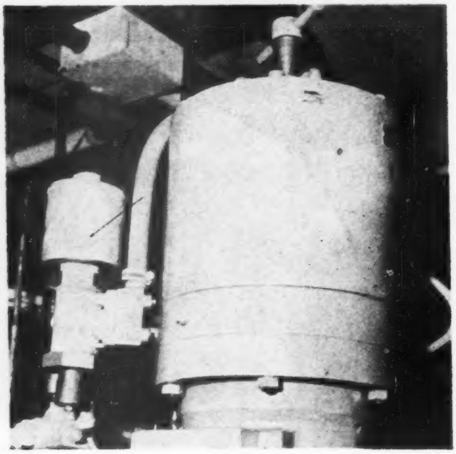

Fig. 4.
Air valve welding machine.

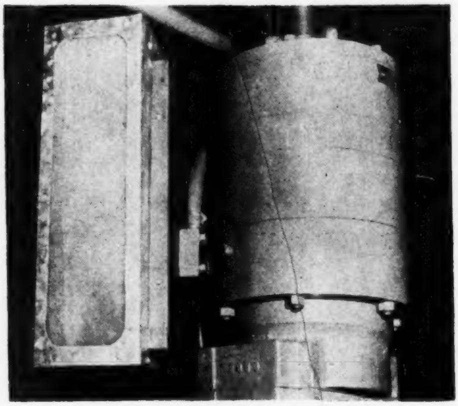

Fig. 5.
Muffler on composite air valve.

Enclosures

H. W. GUTEKUNST

SOME EXAMPLES of noise control by the use of partial and complete enclosures are presented. Results ranged from unsatisfactory on the use of a partial enclosure around the cold header, to excellent on the complete enclosure for the gasoline engine. Information presented herein is not to be considered the ultimate in noise control, but rather to demonstrate results of some initial attempts at designing enclosures.

Axle Housing

FIGS. 1 and 2 show two views of a cabinet consisting of fiber glass sandwiched between steel panels. This total enclosure is used to enclose a rear axle housing while it is being hammered to remove rust and chips from the surface. This was an early attempt at noise reduction and for that reason no attenuation data is available. It can be stated, however, that the enclosure reduced the noise level of the operation below that of the surrounding operations and eliminated employee complaints in the area.

Cold Header

FIG. 3 shows a partial enclosure around a cold header. Figs. 4 and 5 show the header without the enclosure and an inside view of a panel showing the type of construction. Attenuation attained with this type of enclosure and construction was not satisfactory for this particular operation. Partial enclosures made of light plywood and acoustical tile are not effective in confining low frequency noise. Also no vibration mounts were used between press and enclosure.

Verson Press

FIG. 6 shows the start of a complete enclosure around a Verson Press. Fig. 7 shows one side of the completed enclosure. Fig. 8 is a view of openings for stock entry, windows and an access door for making minor adjustments on the press. Construction on this enclosure was a two by four frame covered with plywood panels lined with acoustical tile. An 8 db. reduction was measured using this enclosure.

Enclosure for Gasoline Engine

FIG. 9 shows an enclosure around a gasoline engine used to drive a dynamometer for testing transmissions. Fig. 10 shows an end view of the booth with door open and engine in place. It also shows the ventilation ducts. Fig. 11 is a general view of 14 booths installed in the test area. Fig. 12 is a cutaway of the type construction used in making the booths. The booth consists of an outer wall of 18-gauge steel, to which one

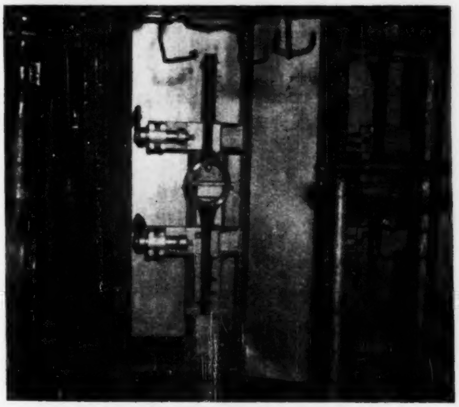

Fig. 1.
Enclosure for rear axle housing—open.

Fig. 2.
Enclosure for rear axle housing—closed.

Fig. 3. (left) Cold header—one side covered. Fig. 4. (center) Cold header without enclosure. Fig. 5. (Right) Cold header showing type of enclosure.

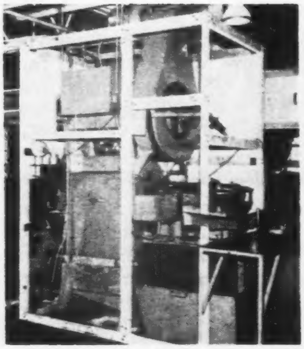
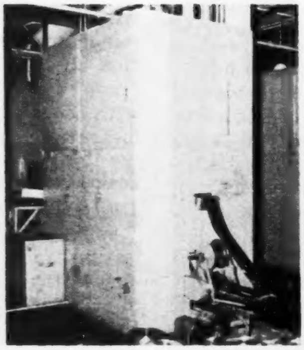
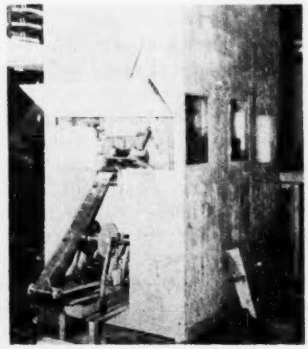

Fig. 6. (left) Verson press enclosure showing construction. Fig. 7. (center) Verson press enclosure. Fig. 8. (right) Verson press enclosure showing total enclosure and openings.

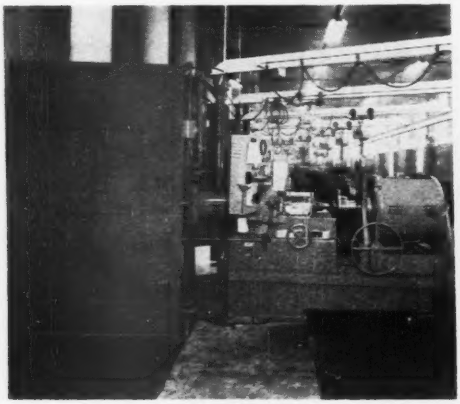

Fig. 9.
Total enclosure around gasoline engine.

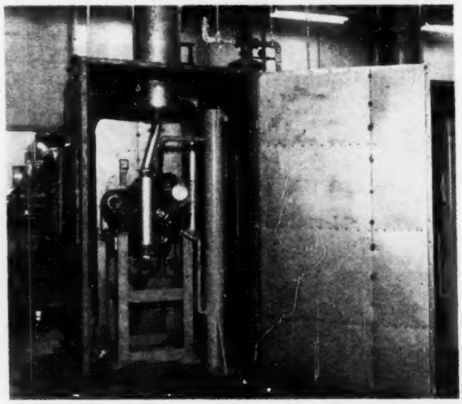

Fig. 10.
End view of booth showing engine in place and ventilation ducts.

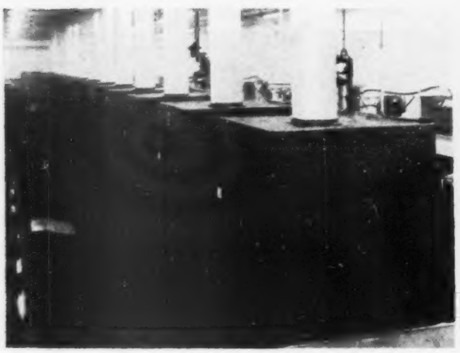

Fig. 11.
General view of 14 booths.

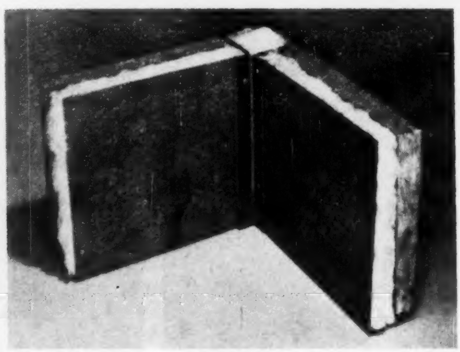

Fig. 12.
Type of construction used in making engine enclosures.

inch of pressed fiber glass was glued. An intermediate wall of 18-gauge steel was laid against the opposite side of the pressed fiber glass, but in no way rigidly attached to the outer wall. On this, was placed three inches of fiber glass blanket, compressed to one and one-half inches and held in position by perforated metal panels. Openings were: (1) The whole rear panel built as a door to enable replacing the engine when necessary. Door was hung on two large strap hinges and equipped with an explosion hasp. (2) Two smaller doors on each side of booth hung on piano-type hinges and equipped with explosion hasps. These doors are used for servicing the engine. (3) Ventilation and engine exhaust port in the roof of the booth, intake or fresh air supply duct, 16 inches in diameter, was reduced to 14 inches by lining the entire length from the booth top to the upper plenum with one inch of pressed fiber glass. Distribution ducts were attached to the 16-inch duct at the ceiling and extended to the floor of the booth to insure good air circulation. Inside the 16-inch duct, an 8-inch duct was placed to serve as the booth exhaust. This was attached to a manifold and exhausted outdoors. (4) A 3-inch diameter hole was made in the front of the booth for the drive shaft. A split cylinder, of similar construction as the booth, was attached over the hole and around the complete drive assembly. (5) A few small holes for the throttle, gas, water and tachometer connections were made in the front panel, to almost exact size so that very little noise escaped.

The whole booth was set on two inches of cork and bolted to the wood block floor. All the cracks around the cork and floor were caulked with a suitable caulking compound. A 35 db. attenuation was attained.

Compressed Air Exhaust Mufflers

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Pneumatic presses often are used in steel products fabricating shops for metal forming and riveting. Since the air may be discharged from the cylinders of the presses at pressures in the order of 100 to 150 lbs./sq. in., an objectionable noise is created by the exhaust jet. Such noise can be reduced by appropriate mufflers.

Fig. 1 shows a partially assembled homemade model of a muffler designed for a large stationary press. When assembled, the section at the right of the figure is inverted and bolted concentrically over the section at the left. Air then enters through the perforations in the bottom plate shown in the section at the left of the figure, flows along the inner cylinder, is deflected into the annular space between the cylinders and

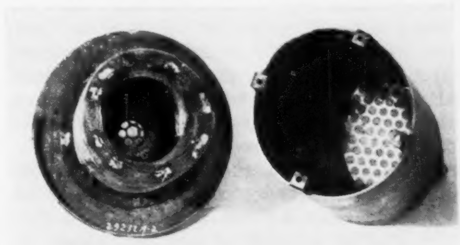

Fig. 1.
Partly disassembled muffler showing construction.

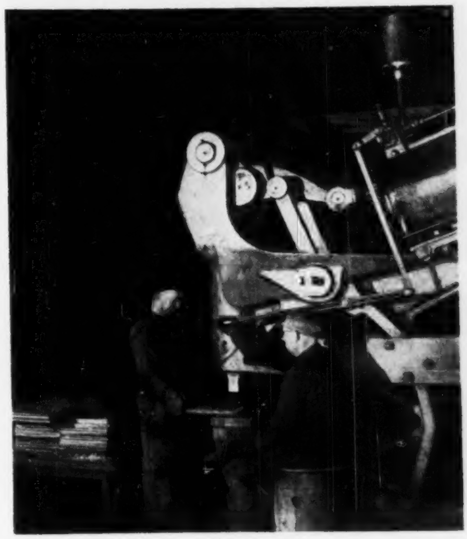

Fig. 2.
Muffler of Fig. 1 assembled and installed on 100 ton press.

is exhausted through the slots between the outer cylinder and the bottom plate. The perforations restricting the inlet were provided to reduce the possibility of an explosion should the lining slip and restrict the muffler outlet.

The sound absorbent lining consists of a glass fiber pad ½ inch thick attached to the steel with adhesive and covered with window screen to reduce erosion. A perforated plate is added to the end lining of the outer cylinder because of the severe erosive conditions at this "bend."

The muffler is shown assembled and installed on a large press in Fig. 2. The deflector attached to the bottom plate is oriented to direct the exhaust away from the workmen. This muffler eliminated entirely a high noise peak at the onset of exhaust and reduced the ensuing nearly constant level noise burst in the three octave bands above 1200 cps by 11, 13 and 22 db. respectively. Since the exhaust noise was concentrated in these upper bands, the noise reduction obtained was quite satisfactory.

A smaller muffler of similar design installed on a portable press is shown in Fig. 3. There is a perforated plate at the entry, and the same glass fiber and window screen lining is used. Because of the smaller size required for portability, the noise reduction obtained with this muffler is less than in the previous case.

Fig. 3.
Small muffler installed on 60 ton press.

Vibration Damping for a Saw Sharpening Operation

JAMES H. BOTSFORD

Large circular saws for cutting hot metal are sharpened by grinding teeth around the periphery. The grinding causes intense vibration of the saw since it is supported only by a central hub and a bearing pad near the grinding wheel. Objectionable noise is radiated from the vibrating surface of the saw.

It was decided to attempt to reduce the noise by damping out the saw vibrations, thereby decreasing the radiated noise. The method chosen to obtain this damping was to place a material of high internal friction in such a position that it must be alternately compressed and relaxed as the saw vibrated. The motion of the saw would be impeded by the frictional forces within the damping material and the vibrational energy dissipated as heat. This removal of energy would reduce the amplitude of saw vibration. Obviously, the greatest damping would be obtained through this scheme by covering as much of the saw area as possible with the damping material.

A vibration damper constructed after this plan is shown applied to a saw in Fig. 1. It is essentially a plywood disk attached to the central hub which presses a glass fiber pad against the saw. As the saw vibrates, the glass fiber pad is compressed between the saw and the plywood disk and the resultant rubbing of the fibers and flexure of the binder dissipate the energy of vibration.

The vibration damper produced noise reduction in each of the octave bands above 1200 cps varying from 4 to 10 db., depending on the percentage of saw area covered by the damper. Since the grinding noise was concentrated in these upper bands, a reduction in overall level of at least 6 db. was obtained in every case.

It is unlikely that the maximum possible noise reduction has been obtained with the use of glass fibers. Certainly other materials such as felt, particularly the kind impreg-

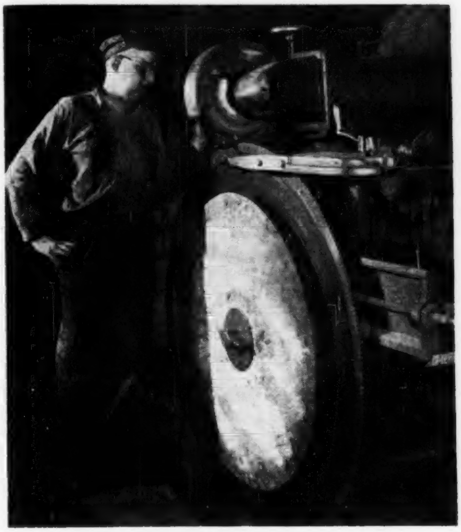

Fig. 1.
Vibration damper installed on saw blade being sharpened.

nated with asphalt, would do as well if not better. However, a less compliant damping material would require more rigid backing than was used here.

Enclosures for Noise Reduction in the Factory

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WHILE it is generally acknowledged that the most satisfactory means of sound control involves reduction of the noise at the source itself, such an approach is not always practical in factory problems. In fact, in some cases, such as with a vibration fatigue machine, noise is a necessary by-product of the desired action itself. In such an event, the best approach is simply to control the noise as close to the source as possible.

Pneumatic Fatigue Machine

SUCH A SCHEME was successfully applied to a small pneumatic fatigue machine. In this case, the entire machine was small enough to be placed inside a sound treated box with a door for easy access as illustrated in Fig. 1.

The machine, shown in Fig. 2, produces a high pitched tone due to the vibration of the turbine blade under test. The frequency may range from several hundred to several thousand cycles per second, depending upon the type of blade.

With the treatment shown, a sound attenuation of more than 50 db. was obtained. In fact, treatment was so effective that observers often thought that closing the door turned off the machine. The walls of this box are of one-inch thick transite to provide mass for the sound attenuation. The inside of the box is treated with Johns-Manville Airacoustic. Outlet for the air necessary to the operation of the machine is provided for in the slots shown on either side of the machine itself. These slots are entrances to narrow sound treated ducts which have two 180 degree bends; they go to the back of the box, and then forward, and then back again and exhaust to the atmosphere at the rear of the box.

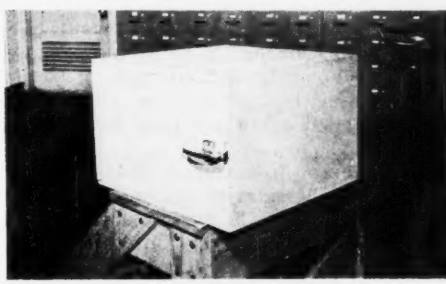

Fig. 1.
Sound treated box for pneumatic fatigue machine.

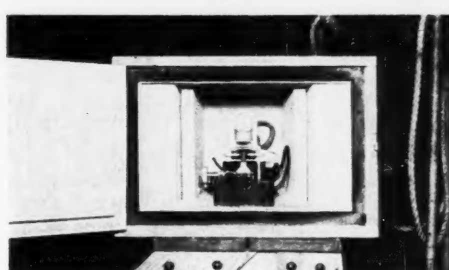

Fig. 2.
Pneumatic fatigue machine with treated box.

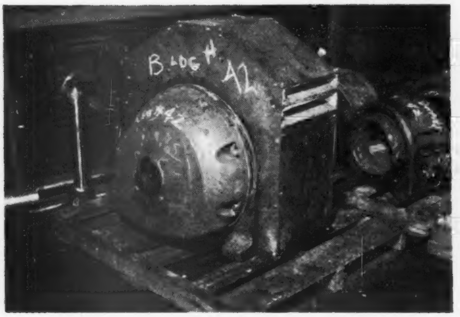

Fig. 3.
Sound treated hood in place over alternator.

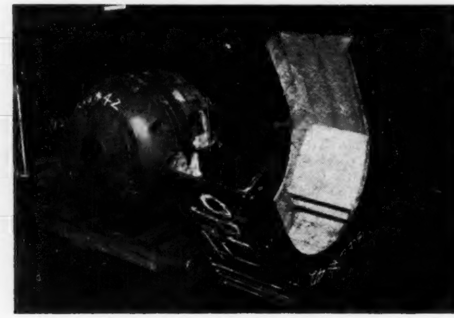

Fig. 4.
Interior of sound treated hood for alternator.

High Frequency Alternator

A SOMEWHAT similar treatment was applied to a noisy high frequency alternator. See Fig. 3. In this case, we desired to enclose as little of the machine as possible. The noise is high frequency, 800 cycles and above, largely due to slot passing frequencies. Cooling is provided by bringing the air in through ducts at the bottom of the end bells. A centrifugal blower then circulates the air through the machine and exhausts it through ports in the center section. The housing shown over the center section was constructed with metal sheets and lined with fibreglass on the inside. Sound treated ducts are provided for the exhaust air.

Fig. 4 shows the interior of the housing and the sound treatment and duct work provided. Silencing at the air intake in the end bells was accomplished by lining the intake ducts with fibreglass. This treatment provides sound attenuation of the order of 15 to 20 db. at the high frequencies, where such reduction is most desirable.

Jet Engine Test Cell Control Room

THE SOUND LEVEL inside a jet engine test cell is quite high and personnel are not permitted to enter the cell during tests. The top curve in Fig. 5 shows the approximate spectrum in the neighborhood of the walls inside such a test cell—when a jet engine is operating with an after-burner. The lower curve was obtained by subtracting from the top curve the attenuation provided by a one-foot thick concrete wall. This curve then represents the level which would exist in a control room for the jet engine which was isolated from the engine by means of a one-foot wall of concrete. This, of course, neglects any sound leakage through observation windows, door seals, around fuel lines, etc.

In Fig. 6, the dotted curve shows the same spectrum (after the attenuation of the one-foot wall) now plotted on a background of speech interference criteria as proposed by the acoustic consulting firm, Bolt, Beranek, and Newman. The speech interference levels tabulated here are the averages of the sound pressure levels of the contours in the three octave bands from 600 to 4800 cps. These bands are chosen since they approximate the frequency range required for understanding normal speech. The intensity of a noise within this frequency range is thus indicative of how effectively the noise will mask speech.

Now, the dotted curve appears to be in the range of intermittent to minimal com-

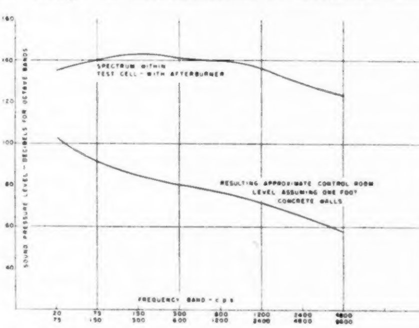

Fig. 5.
Noise level in test cell with engine operating with afterburner, and noise level in control room when separated from test cell by one foot thick concrete wall.

munication. This means that a very loud voice would be required for communication at distances of two or three feet and that shouting would be necessary for a greater distance. Such conditions are not considered to be desirable for work of a developmental nature. However, thicker walls between the jet engine and the control area cannot provide a practical solution, since doubling the thickness of such a wall would only give about 5 db. more attenuation. Hence, for most effective sound isolation, it is necessary to build a separately walled control room which is vibration isolated from the test cell walls and floor. At our Evendale Aircraft Gas Turbine plant, such a room was constructed with quite good results. The control room walls are of thick concrete and they are treated with a sound absorbent

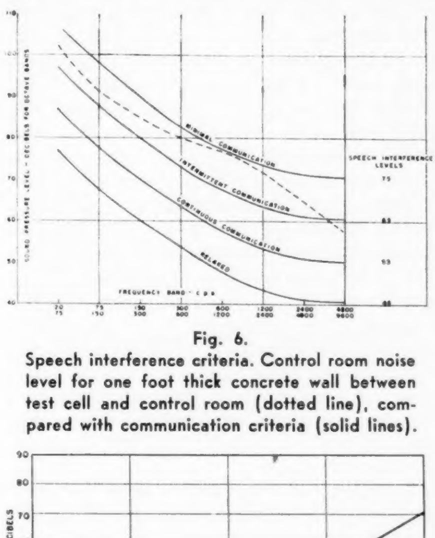

Fig. 6.
Speech interference criteria. Control room noise level for one foot thick concrete wall between test cell and control room (dotted line), compared with communication criteria (solid lines).

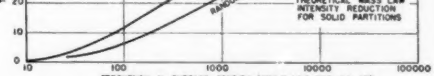

Fig. 7.
Theoretical "Mass Law" giving sound attenuation for rigid partitions. Top curve for normally incident sound waves; bottom curve for reverberant sound.

material on the inside. The entire room is floated on a rubber pad to separate it from the main building structure. The ventilation ducts are sound treated and the observation windows into the test cell consist of triple-thickness bullet-proof glass.

An engine operating with afterburner in this cell is barely audible in the control room and the level approximates the relaxed criterion of Fig. 6.

One interesting comment that has been made by people working in this control room is that they would like to have a P.A. system so that they can listen to the engine occasionally to make sure that it is running properly.

General Design Considerations

FIG. 7 shows the theoretical "Mass Law" sound attenuation for solid partitions. The abscissa scale is the product of frequency in cycles per second and the surface density of the wall in pounds per square foot. The top curve is the sound transmission loss for sound waves which are normally incident against the wall. The lower curve applies to the more general case of reverberant sound. Fig. 8 is a nomogram which may be used to estimate the effect of an opening in a wall or an inadequate door or window. A straight line drawn across this chart, connecting known values of "D" and "r" will give us the value of Delta, which is desired. For example, suppose we start with a 40 db. wall and install a window, using glass which is only good for 20 db. Assume the window occupies but 5% of the original wall. Then "D" which is the difference between the wall and the window attenuation, would be 40 minus 20 or 20, and the "r" which is the area of the original wall divided by the area of the window would also be 20. Hence, we draw a straight line connecting "D" equal 20 to "r" equal 20 and extend it to obtain Delta as 7.5. This means that the resultant average attenuation of the window is now 32.5 decibels instead of 40. This illustrates the need for minimizing windows or any opening through a sound treated partition. Complete openings, of course, are much worse than a thin panel or window.

Fig. 9 is a design chart used to estimate the effectiveness of a baffle which is installed between a noise source and an ob-

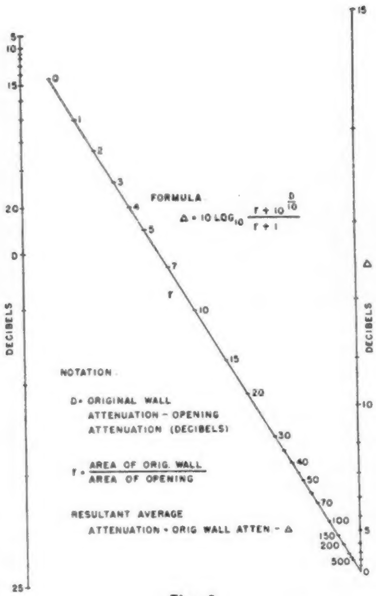

Fig. 8.
Nomogram for computing loss in wall attenuation due to opening or thin section.

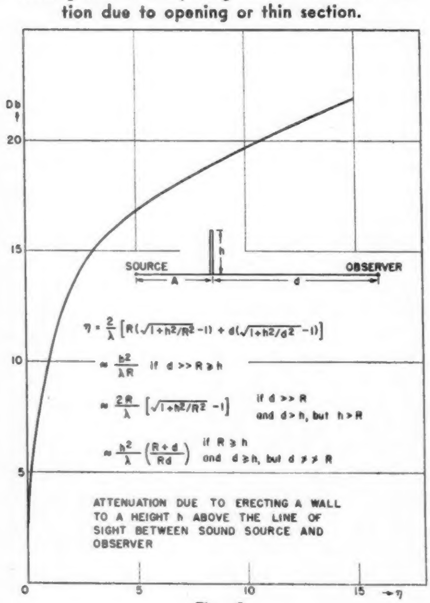

Fig. 9.
Chart for computing sound attenuation offered by barrier in line of sight between noise source and observer.

server. It was primarily designed for use outdoors where free-field sound conditions exist. However, it may be applied to indoor factory noise problems provided sound absorbent material is used on the ceiling and at other critical locations which would, otherwise, give rise to interfering reflections. In other words, if we were to treat the ceiling of a noisy area with the noise stop baffles, which one of the previous speakers mentioned, then this curve would give us an estimate of what further reduction we might expect by putting a baffle in the line of sight between the noise and observer.

On this chart, the abscissa scale merely represents the increase in distance between the source and observer (due to the erection of the wall) divided by one-half the wavelength of the sound being considered. Actually, for any given case, the "n" scale is proportional to frequency. Hence, but little attenuation may be expected from such a barrier at low frequencies, but about 15-20 db. may be obtained at the higher frequencies—provided there are no interfering reflections from machinery, walls, ceiling, etc. For best results, the barrier should be located as close as possible to the noise source and covered with sound absorbent on the side towards the noise.

Summary of Proceedings

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IT IS NO EASY assignment to summarize adequately the large amount of material presented here today. The subject matter dealt with in the formal papers that have been given has been treated in excellent fashion, and the twenty or more examples of solved noise problems are without parallel. All that can be hoped for in this brief summary is to outline some of the cardinal points discussed.

It was shown that exposure to high noise levels over long periods of time may well produce reduction in the hearing acuity of the exposed persons. How high the noise level must be, how long the exposure must be and what percentage of people will be

affected by variations in these two factors remain to be determined. Individual susceptibility is a complicating factor in the noise problem just as it is in the consideration involving the effect of any environmental stress upon exposed persons.

The central impression gained from this meeting is that noise can be controlled. Several papers, the many examples, and most of the discussion were devoted to this premise. It is extremely difficult to find practical solutions to some noise problems, but if engineering know-how and determination are applied, solutions usually can be found. The basic principles of noise control are: (1) eliminate the source; (2) prevent the noise from escaping beyond the source; (3) reduce the level in occupied areas by sound absorption; and (4) protect the exposed persons.

The objectionable noise sometimes may be eliminated entirely at its source by a change in process or equipment. Examples cited today in which this principle was applied include: (1) the substitution of squeeze tools for air hammers; (2) the use of resilient liners in tumbling barrels; (3) the damper applied to large circular saw blades while sharpening; and (4) the use of a tray of water beneath glass for seaming operations.

If the source of objectionable noise cannot be eliminated, the next consideration is to try to confine the noise to its source, or at least to keep it from reaching the areas occupied by employees. Examples discussed today in which this principle was applied are many. They include: (1) mufflers for escape of compressed air; and (2) the enclosures around such items as a small compressor, a rear axle housing cleaning operation, a can divider, and a semi-automatic punch press.

Relatively little discussion was devoted to noise reduction in occupied areas by acoustical treatment. The reason for this probably is that such an approach to the solution of a noise problem is so much less rewarding in terms of noise reduction per dollar spent than is source elimination or enclosure. The only example that comes to mind where this principle was applied as the primary control in today's discussions was in a room housing a number of punch presses. It is important to keep in mind that acoustical treatment of this kind does not decrease the intensity of the primary noise at all, but rather reduces sharply the amount of secondary noise (reverberation from walls, ceilings and other surfaces).

The fourth principle—ear defenders of one sort or another for exposed workers—is resorted to only in those cases where application of the other principles does not accomplish a practical solution. Ear defenders do not reduce the noise in the factory, they merely protect the wearer. Adequate protection is obtained only if the right kind and size of defender is selected. Proper fit is essential, otherwise either the worker will not tolerate the defender or the noise attenuation will not be sufficient.

Lest the analogy be missed, it may be well to remind those engaged in industrial hygiene work and to point out to the others how exactly the same basic principles expounded here today for noise control have been applied to other industrial hygiene problems, especially the control of air contaminants. The first principle in the control of air contaminants is elimination at the source by a change in process or materials. Second is preventing their escape by enclosure and/or local exhaust systems. Third is general ventilation which, like acoustical treatment, does not prevent escape but merely reduces the amount present in the air. And lastly, personal protection in the nature of respirators of one sort or another may be worn by the exposed worker to reduce to a harmless level the amount inhaled.

No doubt there are some present here today who have noise problems unlike any discussed at this meeting. Actually, only a relatively few specific problems can be covered in a one-day meeting. This may seem unfortunate, but the important thing is (1) to gain an understanding of the underlying principles of noise control; (2) to observe how these principles have been applied to the solutions of certain problems; (3) to recognize that few packaged or standard remedies are available in the current state of the art; and (4) to understand that most problems are capable of solution. A concerted attack on the factory noise problem is just starting. The problem will be solved, but it won't happen overnight.

The Engineering and Medical Control of a Lead Hazard—A Plant Study

CLARENCE C. MALOOF, M.D.,[1] HAROLD BAVLEY,[2] and GEORGE W. BOYLEN[3]

THE SUBSTITUTION of a non-toxic material for a highly toxic material may be the simplest preventive of an industrial disease; however, many substances, although possessing toxic properties, must be used in various industrial processes. In these cases, one must rely on engineering and medical control programs to prevent occupational diseases resulting from excessive exposures to these materials.

Lead is a substance that, although possessing toxic properties, cannot readily be eliminated from certain industrial processes, due to its valuable assets. Recently an opportunity presented itself to see and reaffirm the doctrine that a good engineering and medical control program can overcome the serious problems encountered when lead compounds are not handled properly. The plant in question was one which manufactured plastic sheeting, where lead compounds in the form of basic lead carbonates and lead silicates are weighed and mixed into plastic powders.

Our first cognizance of the problem at this plant occurred when we received a request from the plant nurse for urinalyses on three men who worked in this Department, who were experiencing signs and symptoms suggestive of lead intoxication. The results of these urinalyses (Table I) indicated that this Department had a problem that called for the immediate development of a good engineering and medical control program.

The initial investigation at the plant to evaluate the hazard revealed that improper handling of materials, poor location of receptacles, and lack of mechanical ventilation to control the dust at its source of generation, had resulted in considerable contamination of the atmosphere in this Department. The first operation involved transferring the lead compounds by means of a hand scoop from standard cardboard drums to a bench scale located approximately five feet away and in the center of the room. During this movement, considerable lead dust was dispersed into the working atmosphere or was dropped on the floor, as evidenced by the accumulation of lead compounds observed. The floor, scoop, scale parts, and bench were heavily contaminated. A further source of atmospheric contamination occurred during the transfer of the lead compounds from the scale pan to the paper bag container which was then carried to the mixers. The lead compounds and the plastic constituents were dumped into an open dough-type mixer. It was noted that after the powdered lead compound was dumped into the mixer, the paper bags were thrown onto the floor, resulting in dispersion into the atmosphere of the remaining dust. After mixing, the moist compound was dumped into small metal boxes and conveyed out of the room.

Natural ventilation was relied upon in this Department to control the atmospheric contamination. No special attention was given to proper working practices because it was erroneously believed that the handling of the lead compounds in small lots of four to eight pounds did not constitute a potential occupational disease hazard to the 21 employees in this Department. As evidence of the atmospheric contamination in this Department, even samples taken of the general air (Table II) near an open rear door which was well away from the weighing and mixing operations showed concentrations of lead in air greater than twice the maximum allowable.

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[2]Engineer, Massachusetts Division of Occupational Hygiene, Boston.

[3]Chemist, Esso Standard Oil Company, Linden, New Jersey, formerly chemist, Massachusetts Division of Occupational Hygiene.

In cooperation with the plant management and the compensation insurance carrier, plans for an engineering and medical control program were immediately drawn up. Pending the inauguration of this program, it was recommended that all workers who were exposed to the lead hazard in this Department be provided with and required to wear approved respirators. However, it was not intended that the use of respirators would be considered a satisfactory solution to this problem, since it was observed that the men frequently partially removed the respirators to carry on necessary conversation and removed them entirely during periods when they mistakenly assumed that there was no atmospheric lead present.

As part of the engineering program, a ventilating system was installed in this Department in an effort to control the dispersion of the dust at two main sources, namely, the weighing and mixing operations.

The weighing operation which was formerly carried out in the open room is now performed in a small physically separated room (Fig. 1). The drums containing the lead base compound are located in this little room in proximity to the weighing scale. In order to reduce the distance which the balance pan must be moved, the paper bags

TABLE I.

		Initial Study			One Month Later			Two Months Later			Three Months Later			Six Months Later		
		Lead Mg. per Liter*	Coproporphyrin Mg. per Liter*	Stippled RBC (Percent)	Lead Mg. per Liter*	Coproporphyrin Mg. per Liter*	Stippled RBC (Percent)	Lead Mg. per Liter*	Coproporphyrin Mg. per Liter*	Stippled RBC (Percent)	Lead Mg. per Liter*	Coproporphyrin Mg. per Liter*	Stippled RBC (Percent)	Lead Mg. per Liter*	Coproporphrin	Stippled RBC (Percent)
Group A	A.D.			0.1	0.18	0.20	0.0	0.09	0.15	0.0	0.09	0.10		0.09	0.05	
	L.D.										0.18	0.10		0.12	0.10	
	I.G.			0.2	0.17	0.50	0.0			0.01	0.24	0.25		0.12	0.30	
	A.G.										0.07	0.10		0.16	0.15	
	R.G.			0.2	0.30	0.50	0.1			0.0	0.32	0.55		0.18	0.20	
	S.G.									0.0	0.17	0.15		0.14	0.20	
	J.N.			0.0							0.13	0.0		0.14	0.05	
	C.R.										0.14	0.30		0.16	0.20	
	O.R.			0.2	0.18	0.20	0.0	0.14	0.15	0.0	0.11	0.00				
	†L.T.	0.31	0.50	0.9	0.28	10.0		0.21	2.80	0.1	0.12	3.00		0.08	0.20	
	†S.W.	0.45	2.50	0.4	0.32	2.80		0.20	0.65	0.0	0.17	0.30		0.10	0.15	
	†N.L.	0.91	1.65	0.1	0.34	1.30	0.0	0.31	0.55	0.0	0.21	0.35		0.12	0.10	
Group B	F.M.			0.1	0.26	0.50	0.0	0.16	0.35	0.0	0.08	0.10		0.09	0.10	
Group C	F.G.													0.05	0.10	
	B.B.										0.07	0.15		0.10	0.10	
	C.B.									0.0	0.08	0.10		0.08	0.05	
	O.B.									0.0	0.05	0.10				
	A.C.										0.14	0.05		0.11	0.15	
	B.D.										0.16	0.00				
	J.W.													0.08	0.10	
	J.K.													0.17	0.20	

†Hospitalized for plumbism
*Adjusted to mean Specific gravity (1.024)

TABLE II.

Sample Number	Location	Mg. of Lead per Cubic Meter of Air: Initial Study	Ventilation Installed
1	Work on platform	0.48	0.09
2	Near platform scales, weighing, charging and mixing	5.30	0.08
3	Emptying mixer	0.40	0.13
4	On platform, weighing and charging	1.50	0.05
5	Inside booth, lead weighing	3.50	1.69
6	Inside booth, lead weighing	—	0.35
7	Inside booth, no lead weighing	0.27	0.09
8	Near rear door, general air	0.36	0.06
	Maximum Allowable Concentration	0.15	

have been relocated directly in front of the weighing scale. Local exhaust ventilation has been provided by means of a metal duct eight inches in diameter located four inches above the balance pan. The average

Fig. 1.
Weighing operation: Employee using hand-scoop to place lead compound into balance pan. Operation carried on within small room. One door kept closed during weighing operation. Air sample is being taken during the handling operation.

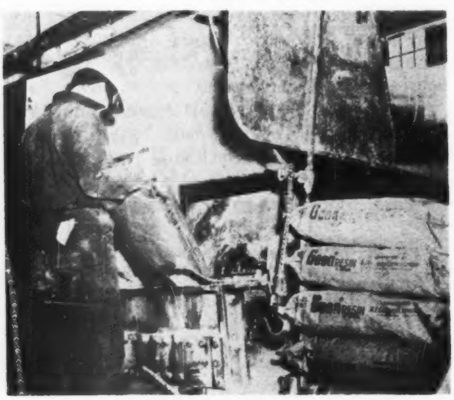

Fig. 2.
Mixing Operation: Operator dumping various ingredients into a ventilated mixer.

linear velocity at the pan is 175 feet per minute. The linear velocity through the single door opening also averages 175 feet per minute. Since there is an inward velocity through the door opening, any lead-base material dispersed during the weighing operation does not enter the main Department. When air analyses showed that the atmospheric contamination was still high as a result of the working practices of the operator, it was recommended that the operator be provided with and required to wear a respirator approved for lead dust. By careful handling of the lead dust in the scoop and balance pan, the use of the respirator can be eliminated. The weighing operation is carried on intermittently about three or four times a day, lasting approximately one-half hour each time.

Each mixer has been provided with a semi-enclosed canopy-type hood (Fig. 2), which is ventilated so as to induce a face velocity of 160 feet per minute at the outer edge of each mixer. The ventilation is provided through an opening at the rear of the hood at the rate of 2,900 cubic feet per minute. Since only one mixer is used at any one time, shut-off dampers have been provided in the branch ducts. To increase the face velocity further, it was recommended that the sides of each hood be extended downward an additional 18 inches.

The hood does not extend far enough over to cover the mixer when it is in the discharging position (Fig. 3); however, there is sufficient airflow so that there is an induced air movement towards the hood. Also, the material has been moistened so that the dispersion of the mixed product is at a minimum.

To control the dust dispersion resulting from the mishandling of the emptied bags at the mixing operation, it was recommended that the paper bags containing the lead compounds be so marked, and after being emptied, the edges of the individual bags be rolled together and folded over before they are thrown onto the floor.

To improve general housekeeping and to assure the efficient removal of the accumulation of powdered material from the floor, conveyor, machinery, and equipment, it was recommended that an industrial vacuum cleaner be provided and utilized at regular intervals. It was suggested that the exhaust

Fig. 3.
Unloading Operation: Unloading of moist ingredients into conveyor boxes. Air sample being taken during operation.

of this unit be led outdoors to prevent possible recirculation of the contaminated air.

Although adequate washing facilities were available, there was no suitable location for the eating of lunches. Formerly, the employees in this Department ate their lunches within the contaminated area. It was therefore recommended that an appropriate location be provided for the consumption of food.

The medical control program was instituted with the full cooperation of the plant physician and nurse. Screening tests designed to reveal obvious signs and symptoms of lead intoxication were performed by the plant Medical Department at first weekly, and then as the engineering control program began to take effect, were extended to a monthly basis. During this study, urinalyses for lead and coproporphyrin were performed periodically by the Massachusetts Division of Occupational Hygiene. These analyses were correlated with complete blood examinations carried out by the plant physician. The workers who, upon examination, showed early signs and symptoms of lead intoxication or who had high urinary lead and coproporphyrin values or a combination of both, were rotated to jobs which did not present a potential lead hazard. Upon our recommendation, the plant purchased the necessary apparatus to perform semi-quantitative tests for urinary coproporphyrin. These tests were performed routinely by the plant nurse in conjunction with the plant physician's screening tests.

The results of the urinalyses for lead and coproporphyrin were carried out periodically on the workers in this Department for the entire period of study as shown in Table I. These values clearly indicate the results that may be obtained by job rotation and sound engineering control measures. Group A consisted of workers who were rotated, and it may be seen that there is a progressively downward trend in both their urinary lead and coproporphyrin values. Three of the men in this group (N.L.; L.T.; and S.W.) had been hospitalized for lead intoxication at the beginning of this study. Group B consisted of only one man who, as foreman, held a key position in the Mixing Department. Since his work was important and he showed no signs or symptoms of early lead intoxication, he was allowed to remain on the job. His values which were indicative of the actual employee exposure existing in this Department during the period of study also progressively diminished. Whereas the values in Group A were due to job rotation, the values in Group B reflected the effectiveness of the engineering control measures. Group C were new employees who, for the most part, replaced Group A. It can be seen that after working approximately six months in this Department, their urinary values are still within normal ranges or very close to them. It can also be seen that the few stippled red blood counts taken by the plant Medical Department during this study likewise showed a progressively downward trend. Although we do not place much emphasis on stippled cell counts alone, it was gratifying to note that there was good correlation between these values and those for urinary lead and coproporphyrin.

Discussion

IT IS BELIEVED that this study, although not presenting any new discoveries in the field of industrial hygiene, does bring out several points which emphasize the application of certain basic industrial hygiene principles. We know that a toxic substance, such as lead, if not properly handled, will

produce illness among the exposed workers, with accompanying economic loss to both employer and employee. This study shows that such a toxic substance can be utilized safely when a good plant engineering and medical control program functions properly. We have as an example a plant which was suddenly confronted with three cases of lead intoxication among the workers because this substance was handled and used without due regard to its toxicity. By the installation of a much needed ventilating system, rotation of all workers with high urinary lead and coproporphyrin values, institution of a good housekeeping program, and the scrupulous follow-up of the other workers by medical screening tests, the situation was checked and progressively improved. This study again reveals the importance of urinary coproporphyrin tests as an aid in the early diagnosis and prevention of lead intoxication. In view of the wealth of information made available on this subject in recent years, it is not believed necessary to dwell on this aspect of this study, except to point out that in all cases there was good correlation between urinary lead and coproporphryin values (Table I). Comparison by means of the statistical method revealed that the coefficient of correlation was .965, with the probable error amounting to .021. This is further evidence for the interdependence to a very high degree of these two values. It has again been shown that the plant medical personnel can perform and utilize the urinary coproporphyrin tests in conjunction with the medical screening tests to detect early signs and symptoms of lead intoxication in workers exposed to this potentially dangerous hazard.

Summary

A STUDY has been presented which revealed how, with the cooperation of the plant management, an effective engineering and medical program can be instituted to control a serious lead hazard within the plant.

Acknowledgment

WE GRATEFULLY acknowledge the assistance rendered by MRS. AGNES W. STONE, R.N., Plant Nurse for the Southbridge Finishing Company, Southbridge, Massachusetts.

Airless Spray Painting

A NEW TECHNIQUE has been developed which promises great improvement in spray painting. This technique eliminates the use of compressed air which in common spray painting procedures caused over-spray or rebound, resulting in the loss of paint and in excessive exposure of the painter. Instead of air, this new method utilizes heat and pressure. Paint is heated to 160 to 200° F., depending on the type of paint, and is circulated between the gun and the heater. A compressor in the system maintains a pressure of 300 to 600 p.s.i. Circulation is necessary to keep the paint hot and prevent clogging. The gun itself consists only of a trigger and a nozzle. Spray characteristics, volume and angle of spray are controlled by nozzle selection. The hose has a bursting test of 3000 p.s.i. or higher and is designed to withstand the action of hot solvents. The pump is driven by an explosion-proof motor, usually ¾ HP, and a 4 KW heater is used. Both heater and pump are approved by Underwriters' for hazardous location use. Atomization of the paint is accomplished by the nozzle design, and by vaporization of part of the solvent being suddenly released at high temperature and pressure.

The biggest single advantage to this new process is the reduction of paint loss due to over-spray. Preliminary reports (the units have been in production use for only a short time), indicate that about twice as much surface can be painted per gallon of paint as with ordinary spray methods.

Accompanying the reduction in over-spray is the reduction in exposure to the painter or other persons in the vicinity. While booths are still desirable to remove solvent vapors in production painting, the air flow can be reduced greatly, and water wash booths will be found unnecessary in most cases. Maintenance or intermittent painting can usually be carried on without need for exhaust ventilation. Other advantages reported are the elimination or reduction of the paint mist nuisance accompanying painting or building interiors, bridges, etc., better finish and better adhesion.

METHODOLOGY OF A COMPREHENSIVE

Air Pollution Investigation

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THE DESIGN of a comprehensive air pollution investigation will depend not only upon local factors, but upon (1) the legal authority of the investigating groups, (2) the type of results desired, (3) the probable application of results, and (4) money available. A distinction should be made between emergency studies and long term studies. An example of the former is the Donora Air Pollution Investigation designed by the U.S. Public Health Service and the U.S. Weather Bureau. In this instance a disaster had occurred, hastening the deaths of a number of people and causing thousands to become ill. It was imperative to study the episode so that measures could be taken to prevent a recurrence. The study was designed, therefore, to accomplish this objective, and it is very gratifying to state that from the results of the investigation, recommendations were made which, if complied with, should prevent another disaster in that area. Because of the seriousness of the problem, the intense emotions aroused, and the speed necessary to complete the investigation before a recurrence, the Federal agencies decided to undertake the entire investigation, using only their own personnel and providing all the necessary funds. This method of conducting an investigation is advisable only in the case of an emergency.

A good example of a long-term comprehensive air pollution study is the investigation in the Detroit-Windsor area under the sponsorship of the International Joint Commission.* This study will provide the basis of most of the following presentation.

Presented before the Joint Technical Program of the American Geophysical Union and the American Meteorological Society, September 12, 1952.

*The author is Chairman of the United States Section, Technical Advisory Board on Air Pollution, International Joint Commission.

The International Joint Commission, established in 1909 by treaty between the United States and Canada, has the legal authority to study atmospheric pollution problems along the boundary between the United States and Canada.

As a result of complaints received on both sides of the international boundary concerning air pollutants, the governments of the United States and Canada on January 12, 1949, presented the following joint Reference to the International Joint Commission:

United States Section
International Joint Commission
Washington 25, D.C.
Sirs:

"I have the honor to inform you that representations have been made to the Governments of the United States and Canada to the effect that the air in the vicinity of the cities of Detroit and Windsor on both sides of the international boundary in the area of the Detroit River is being polluted by the discharge of smoke, soot and fly-ash, in quantities sufficient to be detrimental to the citizens of both countries in this area. It has been further represented to the two Governments that vessels passing through the Detroit River are a source of this pollution. Pursuant to the provisions of Article IX of the Boundary Waters Treaty, signed January 11th, 1909, the two Governments have agreed to a joint Reference of this matter to the International Joint Commission. The Commission is requested to inquire into, and to report to the two Governments upon the following questions:

1. "Is the air over, and in the vicinity of, the cities of Detroit and Windsor, on either side of the international boundary, being polluted by smoke, soot, fly-ash or other impurities, in quantities detrimental to the public health, safety or general welfare of the citizens, or to property interests on either side of the international boundary line?

2. "If the foregoing question, or any part thereof, is answered in the affirmative, to what extent are vessels plying the waters of the Detroit River, or any of them, contributing to this pollution; what other major factors are responsible and to what extent?

3. "If the Commission should find that vessels plying the waters of the Detroit River, or any of them, are responsible for air pollution to an extent detrimental to the public health, safety or general welfare of the citizens, or to the property interests on either side of the international boundary line,

(a) what preventive or remedial measures would, in its judgment, be most practical from the economic, sanitary and other points of view?

(b) what would be the probable cost of such measures?

(c) by whom should cost be borne?

"For the purpose of assisting the Commission in making the investigations and recommendations provided for in this reference, the two governments, upon request, will make available to the Commission the services of engineers and other specially qualified personnel of their respective Governments, and such information and technical data as may have been acquired by such Governments or as may be acquired by them during the course of the investigation. The Commission should submit its report and recommendations to the two Governments as soon as practicable.

Very Truly yours,
(signed) Robert A. Lovett
Acting Secretary of State"

"An identical reference was simultaneously received by the Canadian Section of the International Joint Commission from the Department of External Affairs of Canada."

Shortly after the receipt of this Reference, the International Joint Commission established a board of experts, which subsequently became known as the Technical Advisory Board on Air Pollution. The purpose of this board is to give technical direction to the field work and to plan the studies on both the Canadian and American sides of the boundary, to review the findings periodically, to discuss the significance of the data accumulated, and to make recommendations to the International Joint Commission. The board is made up of three representatives of the Government of the United States and three from Canada.

After careful study of the Reference, the board established certain objectives and considered the type of organization necessary to achieve them. The board, after serious consideration, adopted the philosophy that although the International Joint Commission has legal responsibility for the study, the benefits from the investigation would be more lasting if the problem was considered a community one and the communities were asked to participate. The reasoning behind this philosophy was that personnel of Federal agencies conducting the study would be in the area for only a few years, and if the communities' interest could be stimulated during this period, they could continue the work after Federal activity in the area had been completed. Another reason for community participation is that if the cost can be distributed over many organizations, no individual organization would have to stand the large expenditures which are necessary to carry out a thorough investigation.

A statement defining objectives was circulated to all responsible agencies so that there would be no misunderstanding as to the scope and purpose of the investigation. This, of course, is basic, but it is surprising how often there are misinterpretations if the objectives of an investigation are not clearly understood by all concerned. For example, in one community the people have been concerned for many years about the air pollution from certain industries within the area. As a result of these complaints, the city made available a sum of money to a university to conduct an investigation. The city, upon appropriating the money, made public certain objectives. The university, on the other hand, conducted the study with a different set of objectives, and when the report was completed there was considerable ill feeling between the community and the university, as the results of the investigation could not be used in the manner originally desired by the city.

Five objectives have been agreed upon for the Detroit-Windsor study. Briefly:

OBJECTIVE NO. 1: Determination of sources, nature and amounts of atmospheric contaminants resulting from combustion of fuels.

Under this objective, a study will be made to determine the amount of pollution from fuel combustion of vessels, railroads and domestic, industrial and automotive sources. The Ringelmann chart was accepted as the

standard method of estimating the intensity of smoke, and the ASME code entitled, "Example Sections for Smoke Regulation Ordinance" was adopted. We were most fortunate that the cities of Detroit and Windsor each have a well-organized and competent smoke abatement department to aid in this phase of the investigation.

One of the foremost problems—the one, in fact, which instigated this entire investigation—is the smoke from vessels. Although the cities of Detroit and Windsor have had smoke ordinances for many years, with efficient smoke abatement departments to enforce them, neither department has had authority over vessels plying the international waters of the Detroit River. Repeated efforts on their part have had little effect in reducing the quantities of smoke emitted by these vessels as they passed through the Detroit River. Therefore, one of the first studies undertaken was that of smoke emissions from vessels. After several months of investigation, the data were presented to the Lake Carriers' and Dominion Marine Associations and their cooperation was requested in the elimination of this smoke problem. As a result of this meeting, the Lake Carriers' and Dominion Marine Associations joined forces to study the problem, and appointed a committee of combustion experts known as the Great Lakes Air Pollution Abatement Program Engineering Advisory Committee.

An example of this committee's work was the study of the firing behavior of a boiler which had been removed from a vessel. As a result of this study, methods were perfected for the reduction of smoke to within acceptable limits for this type of boiler. Fuel specifications have also been established and an educational program initiated. It is hoped these measures will assist materially in reducing pollution from this source.

OBJECTIVE NO. 2: Determination of sources, nature and amounts of atmospheric contaminants resulting from industrial processes.

To achieve this objective, it will be necessary to obtain mass emission rates from industrial stacks from which toxic materials and other contaminants are being discharged into the atmosphere.

The Technical Board requested the Division of Industrial Health, State of Michigan, to assume the responsibility for obtaining the data from industry within the study area outside of the Detroit city limits. In the city, the Bureau of Industrial Hygiene, Detroit Department of Health, was requested to assume similar responsibility.

An evaluation of the resources of these groups, however, revealed that they needed assistance in undertaking this immense task. Because of the magnitude of the job, it was decided to request industry to supply data on its own stack emissions. A meeting was called, therefore, to outline the study to the representatives of the various industries and to solicit their cooperation. Again, the excellent community spirit that prevails in Detroit and Windsor was shown by the support industry has given to this study.

It should be pointed out, however, that many of the larger participating industries seemed very interested in acquiring more knowledge on methods of sampling and analysis of stack effluents. To meet this demand, a course of one semester was established under the auspices of the University of Michigan, and men with considerable experience in stack sampling presented 18 lectures. The course has now been completed and the material presented has been made available for distribution.

While most of the industries have been able to provide their own data, we recognize that some plants are inadequately staffed with technical personnel to study their own problems. Such plants will be assisted by personnel from the state and city industrial hygiene organizations.

OBJECTIVE NO. 3: Determination of effects of meteorological factors in the area on the dissemination and diffusion of atmospheric contaminants.

This phase of the investigation was undertaken in cooperation with the Weather Bureaus of the United States and Canada. A series of stations for the sampling of the atmosphere for solid and gaseous contaminants have been established in the area under study, and the data obtained from these samples are to be correlated with data obtained by the Weather Bureaus. This correlation of data will indicate the diffusion rates due to meteorological factors, as well as the influence of temperature inversions on atmospheric contaminant concentrations. The data obtained from these general samp-

ling stations will also be used in the studies to determine the effects on health, safety, vegetation and economy.*

OBJECTIVE NO. 4: Determination of the effect of the atmospheric contaminants upon (a) health, (b) vegetation, (c) safety, and (d) economy.

The fulfillment of this objective is probably the most difficult and time-consuming of all. Because of the health implications of air pollution posed by acute incidents, such as Donora, there is great need to study the chronic, or long-range, effects of air contaminants on health. This study is being undertaken as a joint effort by the United States Public Health Service, the Canadian Department of National Health, and the Detroit City Health Department.

A more obvious problem is the evaluation of the effects of atmospheric contaminants on vegetation. Evidences of such effects are apparent in the stunting of growth, loss of vigor, and reduction in crop yield. Air pollutants also present a threat to the civic beauty of a community as well as the prosperity of its outlying farms. Because of its importance, the Technical Board is going to request the assistance of a well-qualified organization to undertake this phase of the study. There is also need to consider the effect of atmospheric pollution on safety. Studies will be undertaken to determine what effects, if any, concentrations of variout contaminants have upon aviation, automotive and pedestrian safety. Appropriate organizations will be requested to participate in a study of the effects of air pollutants on aviation safety. This investigation will also include a study of the economic factors involved in air pollution and its effect on "closed" airports. As can be well appreciated, every hour that airplanes are grounded, the economic loss is considerable. The United States Weather Bureau and members of the Technical Board will cooperate in its undertaking. The studies on automotive and pedestrian safety will be planned in cooperation with the City of Detroit and other interested organizations.

OBJECTIVE NO. 5: The determination of (a) cost of controls necessary, and (b) by whom should the cost be borne?

*Those desiring further information on the meteorological aspects of the study should write to Dr. Harry Wexler, Chief, Scientific Services Division, U.S. Weather Bureau, Washington 25, D.C.

This objective applies only to the vessels and is being considered by the Board and representatives of the Lake Carriers' and Dominion Marine Associations.

In concluding, I would like to emphasize four cardinal considerations to which we must adhere, if an air pollution investigation is to be successful. These are so basic that they might apply to any investigation. These considerations are:

1. *Definition of Objectives.* A very clear understanding should be established with all interested parties as to the type of results desired from the investigation.

2. *Adequacy of Funds.* After the objectives have been established, it must then be determined if there are sufficient funds to carry the study to the accomplishment of these objectives. Few people appreciate the tremendous expenditures involved in conducting even a moderate air pollution study. If funds are not adequate, consideration should be given to modifying the objectives, in order that the work that is done will be of optimal scientific value.

3. *Cooperation between Agencies.* There are few organizations in the United States today which can conduct a comprehensive air pollution investigation without aid from other groups. For instance, it is neither wise nor desirable for the Public Health Service to enter into the field of meteorology. On the other hand, it is equally inappropriate for the Weather Bureau to consider a study to determine the health of the populace. Whenever possible, it is desirable to enlist the cooperation of those agencies or organizations with special talents. From a Federal level, there is still another reason for enlisting the aid of local agencies, as it is desirable that the local agencies continue on with the work, upon the completion of the Federal activity.

4. *Public Relations.* Public Relations is an important facet of any comprehensive air pollution study, especially if the investigation is to include a study on health where the families in a community are requested to cooperate. Proper public relations may be maintained by releasing pertinent information through the local newspapers and other local channels. Our experience to date is that newspapers, radio and related organizations have been very cooperative and willing to assist in every manner possible.

Ultraviolet Emission

DURING INERT-ARC WELDING

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AFTER A SHORT experience with the inert-gas metal-arc welding processes, it became apparent that there was a decided difference in the ultraviolet emission of these processes as compared to the common metal-arc process using heavily coated electrodes. Some of the effects which led to this conclusion were the increase in frequency and severity of the eye and skin burns, the more rapid decomposition of clothing, the increased ozone formation and the rapid decomposition of trichloroethylene vapor in the surrounding air. An attempt was made to learn more about ultraviolet emission of these processes.

Instruments Used

ONLY TWO instruments could be found available commercially which could be used for this purpose and which at the same time were suitable for field work. They were the General Electric Company Germicidal Ultraviolet Intensity Meter and the General Electric Company RS Sunlamp Tester.

The Germicidal Intensity Meter was designed to measure radiant energy produced by germicidal ultraviolet fixtures. It is sensitive to radiation between 2000 and 3000A, with a peak sensitivity about 2537A. Its responsive curve, Fig. 1, supplied by the manufacturer, corresponds closely to the short wave length part of the erythemal or skin reddening curve. It has no response in the near ultraviolet or in the visible or infra-red regions. Prior to use it was calibrated against a germicidal lamp and found to agree very closely with the data supplied by the lamp manufacturer. It may be read on one of three intensity scales: 0-1, 0-10, 0-100 milliwatts per square foot. In use it was found to give steady, reproducible results against sources of steady intensity.

The RS Sunlamp Tester was designed for testing the output of sunlamps. It responds, Fig. 1, to light in the range of about 2200 to 3400A with a peak of about 2900A. There is also a very slight response (not shown in Fig. 1) at 7000A which might be important when testing a source strong in infra-red (as in the welding arc). The manufacturer warns specifically that erroneous results might be obtained by using it to test emissions other than those produced by sunlamps. However, it was felt that the results obtained would be useful on a comparative basis and would give some indication of absolute values. The meter reads in E-vitons per square centimeter. One E-viton is the radiant flux which will produce the same erythemal effect as 10 microwatts of 2967A radiation. Thus the readings can be converted directly to microwatts per square

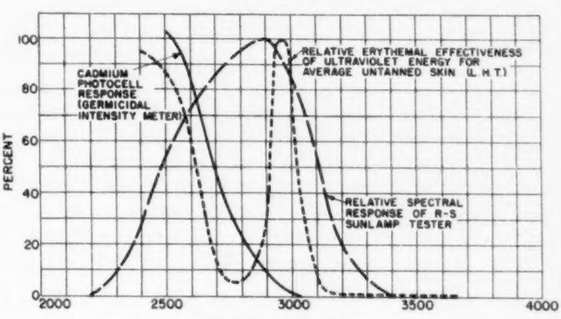

Fig. 1.

This investigation was made possible through the advice and assistance of the Welding Section, Schenectady Works Laboratory.

TABLE I.
ULTRAVIOLET FLUX DURING WELDING

No.	Current Amps	Volts	Gas	Electrode	2967A Measured at—feet	2967A Microwatts per sq. cm.	2537A Measured at—feet	2537A Microwatts per sq. cm.
I.	Inert arc—Straight Polarity No filler metal							
	120	17	Arg.	Tung.	3	72	16	543
				3/32"	3	72	11	900
							16	189
	180	20	Arg.	Tung.	3	86	11	642
				3/32"			21	700
							11	482
							21	584
							16	612
	190	18.5	Arg.	Tung.	3	99	11	804
				1/8"			21	526
							11	738
	120	28	He	Tung.	3	38	11	642
				3/16"			11	1600
							16	1360
							21	1180
							16	1560
							11	2570
	190	20	He	Tung.	3	38	16	3400
				1/8"			21	2920
							16	2720
							16	1360
II.	Stainless Steel Consumable Electrode Machine Welding							
	340	30	Arg. 99%		9	1280	40	4240
			O_2 1%	1/8"	9	1280	40	6360
					9	1280	24	3820
					9	1280	24	2950
					9	1700	19	6690
					14	1080	19	2870
					14	1590	19	4780
							19	5740
							19	2870
							19	3830
							19	5740
							19	2870
							19	4780
							14	3120
							14	4160
III.	Aluminum Consumable Electrode Manual Welding							
	205	28	Arg.	Al.	5	328	35	12985
				1/16"	5	525	35	3246
					10	525	30	2385
					5	590	20	4240
					5	525	15	3279
					10	630	25	6625
					5	590	35	4869
							25	3313
							25	6625
							25	6625
							25	4969
							20	5300
IV.	Copper Consumable Electrode Manual Welding							
	340	26	He	Cu.	5	440	20	1060
				1/16"			10	212
							35	974
							35	1299
	340	26	Arg.	Cu.	5	660	25	994
				1/16"			25	1325
							15	1789
							15	2385
							15	2981
							15	5366
							15	2981

*Results extrapolated to two feet from arc.

TABLE I—Cont'd
ULTRAVIOLET FLUX DURING WELDING

No.	Current Amps	Volts	Gas	Electrode	2967A Measured at—feet	2967A Microwatts per sq. cm.	2537A Measured at—feet	2537A Microwatts per sq. cm.
V.	Bare Steel Wire							
	210	18	None	Steel 1/8″	3	330	16	1020
							11	2240
							16	690
							11	642
							16	1020
							11	962
							16	1020
							11	1620
VI.	Heavily Coated Electrode							
	120	23 DC	None	Steel 1/8″	3	95	16	136
							11	160
							6	143
							16	276
							16	202
	210	27 DC	None	Steel 3/16″	3	142	16	68
							16	68
							3	81
							16	156
							6	38
	320	30 AC	None	Steel 1/4″	4	210	12	380
							7	260
							12	268
							12	330
							12	344
							7	390
							7	390
	200	25 DC	None	Steel 1/4″	5	388	20	106
							15	179
							10	318
							5	76

centimeter of 2967A. When tested against a source of steady intensity, the meter was found to give reliable reproducible results.

Test Conditions

ALL TESTS were made in the welding laboratory, with welding being done by an experienced welder. Welds were made on flat stainless steel plate, using the inert-gas metal-arc (non-consumable electrode) process. While the consumable electrode (aluminum, copper, and stainless steel) was being used with the inert-gas metal-arc process, welds were deposited on base metal of the same composition as the electrode. Welds made to check emission from the metal-arc heavily coated electrode process were made using an AWS Class E6016 electrode and carbon steel base metal.

The intensity of the arc made it necessary to make readings at some distance, three to 40 feet, from the arc. Readings were made at angles ranging from five to 15 degrees above the plane of the welding table. No measurable difference was found within this range. Care was taken to prevent there being any solid obstruction—slag, metal, torch, etc.—between the arc and the meter. The laboratory was provided with good general ventilation which prevented the accumulation of visible fumes during welding. No local exhaust ventilation was used.

It was found that there was a great fluctuation in intensities recorded by the meters. This fluctuation was apparently due to mechanical movement of the arc during manual welding, to lobing, gas turbulence and to absorption by gases or fumes produced by the arc. Originally it was hoped that by taking readings at several different distances, something could be learned about the air absorption of the radiation in question. The rapid fluctuation prevented this. During the tests the needle of the RS Sunlamp Tester fluctuated rapidly over a range of about twenty scale divisions (100 full scale). Its readings were quite consistent under similar conditions. For this reason, relatively few readings were taken under each condition with this instrument. Readings with the Germicidal Intensity Meter,

however, varied widely under apparently similar conditions, and several readings were taken under each condition to show the range encountered.

Results

THE TEST conditions and intensities determined are shown in Table I. The intensities shown have been extrapolated, using the inverse square law, to a distance of two feet from the arc to permit better comparison and to give a better picture of the actual exposure of the welder. In making this extrapolation, it was assumed that there was no air absorption of the wave lengths measured. Any air absorption would, of course, increase the reported intensities.

Results are shown in microwatts per square centimeter in the 2537A and 2967A wave lengths. 2537A is the peak response for the Germicidal Ultraviolet Intensity Meter. 2967A is the peak of erythemal effectiveness and is fairly close to the response peak, 2900A, of the RS Sunlamp Tester. If the wave lengths present did not fall at these peaks, the true intensities would be greater than those reported. No correction was made for the infra-red response, if any, of the RS Sunlamp Tester.

It is felt that the results shown are reasonably accurate on a comparative basis. The absolute accuracy is probably questionable, since the instruments were not designed for the specific purpose for which they were used. However, it is felt that the results are useful in that they show, at least, the order of magnitude of the intensities in question.

Physiological Effects of Ultraviolet

BLUM[1,2] and Koller[3] have reviewed the effects of ultraviolet light. Some of the more important effects reported are:

(1) Skin Burn: Fig. 1 shows the relative effectiveness of various wave lengths in producing erythema (skin reddening). Minimum perceptible erythema (MPE) is produced on untanned skin by 250,000 ergs per square centimeter (25000 μw—sec/sq. cm.) of 2967A. The most effective erythemal wave lengths lie between 2900 and 3000A, and 2500 and 2600A. The degree of erythema depends somewhat on the wave length producing it and on individual susceptibility. The degree of erythema produced by exposure to midsummer noon-day sun in terms of the dose which produces the minimum perceptible erythema (MPE) is as follows:

Relative Exposure Time	Degree
1	MPE
2.5	Vivid
5	Painful burn
10	Blistering

Tanning of the skin is also produced by ultraviolet light, but in this case the wave lengths over 3200A appear to be more effective. Tanning is produced by the migration of pigment from the basal cells to superficial layers and by the formation of new pigment. Some authorities feel that the thickening of the corneum, produced by ultraviolet exposure, plays a greater part in increased immunity to ultraviolet than does the increased pigmentation.

(2) Conjunctivitis: Exposure of the eyes to ultraviolet energy causes conjunctivitis, a painful inflammation of the membrane. In this case, the shorter wave lengths, under 2800A, appear to be more effective, possibly because of the absence of a strongly absorbing horny layer. The eye does not develop any immunity as does the skin. There appears to be little information available as to intensity required to produce conjunctivitis or other effects, but it is undoubtedly far less than that required to produce erythema.

(3) Skin Cancer: It has been fairly well established by statistical data in regard to humans and by experimental work with animals that exposure to ultraviolet light can cause skin cancer. A close relationship between the sunburn and the carcinogenic mechanism is suggested by the fact that both have the same long wave length limit at about 3200A. It seems reasonable to relate the carcinogenic mechanism to the same basic injury to the cells associated with sunburn. Animal experimentation has shown that the carcinogenic wave lengths lie between 2500 and about 3200A. Rusch[4] has shown that the lower wave length limit is probably about 2900A. There is no evidence to show whether these data obtained from animals can be related directly to human skin.

The amount of energy needed to initiate the carcinogenic action is relatively small. Rusch reports 6.3 to 8.4 x 10^8 ergs per square centimeter of effective radiation was adequate when given over a three-month

period. In a later article,[5] he reports that 3.9 x 10^9 ergs per square centimeter produced cancer in 25% of the animals irradiated for three months, but in this case he was giving what was known to be a carcinogenic dose. Blum calculates from the data of Ruffo that 4 x 10^9 ergs per square centimeter produced cancer. Since there is a delay period of two to three months between the radiation and the development of tumors, determination of the exact amount of energy required is difficult.

Discussion

IT WAS EXPECTED that the ultraviolet intensities would be higher during welding with the inert-gas metal-arc processes than during welding with the metal-arc heavily coated electrodes. The higher current density normally used and the absence of flux fumes to absorb the radiant energy would indicate this. This expectation was borne out in most cases, as can be seen in Table I.

This greater intensity during inert-gas metal-arc welding promises to present several problems in the use of this process. The danger of skin burn will undoubtedly increase. Since there is little or no spattering during this process, as compared to coated electrode welding, there is less need for protective clothing. There have been numerous reports of skin burns during inert-gas metal-arc welding, particularly during the use of the consumable electrode. These burns can easily be explained by the intensities shown in the table. An intensity of 3000 μw per square centimeter in the 2537A range could produce the MPE in about ten seconds and a severe burn in a few minutes.

Conjunctivitis will be produced with a shorter exposure time and at a greater distance from the arc. It would be expected that the effects would be more severe. Reflection of the light from walls and ceiling must be considered more carefully.

The possibility of skin cancer formation must be considered if welders work with exposed skin. The carcinogenic dose has been shown by animal experimentation to be in the order of 1 x 10^9 ergs per square centimeter. A total exposure of 30 hours at 1000 microwatts per square centimeter would be equal to 1.1 x 10^9 ergs per square centimeter, somewhat above the dose necessary to initiate carcinogenic action. Just how strong this possibility of skin cancer is depends on how closely animal experimentation can be translated to humans, on the degree of immunity acquired by repeated exposure to ultraviolet, and on individual susceptibility. Unfortunately, few data appear to be available on these subjects.

Summary

COMPARATIVE measurements have been made of the ultraviolet emission during inert-gas metal-arc welding and during metal-arc welding with heavily coated electrodes.

Results show that, for the most part, the intensities produced by the inert-gas metal-arc process were far higher—frequently 10 to 20 times higher—than those produced during metal-arc welding with heavily coated electrodes. This was particularly true in the lower wave length range, 2537A, when the consumable electrode was used with the inert-gas metal-arc process.

The physiological effects of ultraviolet on skin and eyes have been discussed.

[ACKNOWLEDGMENT: This investigation was made possible through the advice and assistance of the Welding Section, Schenectady Works Laboratory.]

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4. RUSCH, H. P., KLINE, B. E., and BAUMANN, C. A.: Carcinogenesis by Ultraviolet Ray—with Reference to Wavelength and Energy. *Archives of Pathology*, 31:135, 1941.

5. RUSCH, H. P., KLINE, B. E., and BAUMANN, C. A.: The Non-Additive Effect of Ultraviolet Light and Other Carcinogenic Procedures. *Cancer Research*, 2:183, 1942.

THE NATIONAL CIO Conference on Safety and Occupational Health, meeting in Chicago January 22-23, called on each international union to establish a department of occupational safety and health under a full-time, qualified director, together with a training course for its members and to have each of its affiliates form a Local Union Safety Committee.

—*Cincinnati Brewery Worker*, February 4, 1954.

✦ Industrial Hygiene Briefs

New Design of Filter Holder For Dust Sampling

A NEW FILTER HOLDER has been designed for sampling of airborne dusts with molecular filter discs. The primary objective in this design was to construct a filter sampler which could be easily handled within the confined area of a dry box used for experimentation with radioactive aerosols. Manipulation of all apparatus within the box is with gloved hands, and it was essential that the design allow the sampler to be held in one hand while the other hand is used to transfer the molecular filter with tweezers. The model which was finally adopted comprises a cylindrical body with a hinged front ring, and opposite the hinge, a cam locking-bar to enable rapid changing of filter discs. The support for the molecular filters was made of screening in order to give an even distribution of air flow with a minimum of air resistance. A photograph of the unit is shown in Fig. 1.

A rubber gasket, fitted into the front ring, is used to seal the filter disc against an opposing machined seat in the main body of the sampler. A slight lip around this seat positions the filter disc in place. This model uses 47 mm. diameter filters and provides a filtering area 38 mm. in diameter. The molecular filters are given mechanical support by a screen backing inserted behind the seat. The cylindrical section at the rear of the sampler is threaded to allow removal or replacement of this screen. The internal dimensions and construction of the sampler are shown in Fig. 2, an assembly drawing of the holder in the closed position.

A threaded section in the front of the sampler was included so that the same filter unit could be used interchangeably with either the cascade impactor or with special sampling probes, each fitted with a matching threaded sleeve.

Although the sampler was designed for use with molecular filter discs, it has been used satisfactorily with other filtration media. Filter papers and filter cloths have been tried, and an air tight seal has been obtained in each case. The filter holder has been used for routine sampling of test atmospheres in the laboratory and may be useful in application to general problems of air sampling with various filtration media.

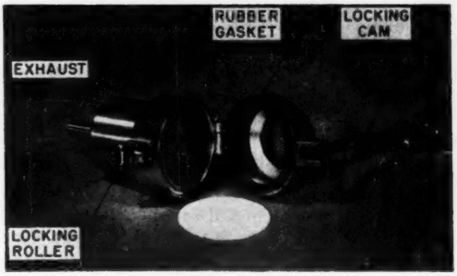

Fig. 1.
The filter holder in the open position.

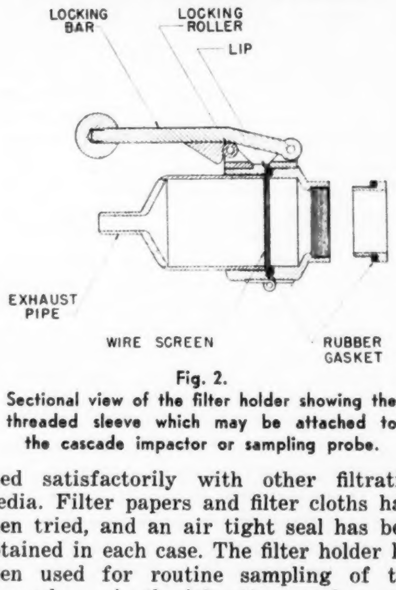

Fig. 2.
Sectional view of the filter holder showing the threaded sleeve which may be attached to the cascade impactor or sampling probe.

—K. E. LAUTERBACH, Division of Pharmacology and Toxicology, Department of Radiation Biology, The University of Rochester School of Medicine and Dentistry, Rochester, New York.

This paper is based on work performed under contract with the United States Atomic Energy Commission at the University of Rochester Atomic Energy Project, Rochester, New York.

Symposium: Instrumentation in Industrial Hygiene

University of Michigan, May 24-27, 1954

PHILIP DRINKER, Sc.D., will be the dinner speaker at the University of Michigan's Symposium on Instrumentation co-sponsored by the Institute of Industrial Health and the School of Public Health.

DR. DRINKER is Professor of Industrial Hygiene at Harvard University and the Chief Editor of the American Medical Association's *Archives of Industrial Hygiene and Occupational Medicine.* He is the co-author of such widely recognized books as "Industrial Medicine" and "Industrial Dust." DR. DRINKER is Consultant to the Atomic Energy Commission and is a former president of the American Industrial Hygiene Association. His special fields are industrial hygiene and toxicology, and air pollution control.

WILLIAM G. FREDRICK, Sc.D., chairman of the Symposium, will deliver the opening address titled "Concepts of the Symposium." DR. FREDRICK is the director of the Division of Industrial Hygiene, Detroit Department of Health, as well as Consultant to the Institute of Industrial Health.

Eight major Symposium speakers will cover with comprehensive review addresses the eight areas of instrumentation of Industrial Hygiene. Both manufacturers and "users" are coming together to exchange ideas and information about what is available and what is needed in the field of instrumentation for air velocity, air pollution, ionizing radiation, sound, and air sampling and analysis. The Symposium is designed to be of interest to the manufacturer, safety engineer, industrial hygienist, physicist, chemist, engineer, meteorologist, and noise investigator.

LESLIE SILVERMAN, Sc.D., Associate Professor of Industrial Hygiene Engineering, Harvard University, will review "Sampling and Analyzing Air for Contaminants in Work Places." HERVEY B. ELKINS, Ph.D., Division of Occupational Hygiene, Boston, will present the paper on "Laboratory Type Instruments of Specific Application to Industrial Hygiene." GEORGE D. CLAYTON, U.S. Public Health Service, will speak on "Instruments Specifically Designed for Atmospheric Pollution Evaluation."

Home-assembled instruments will be discussed by ALFRED N. SETTERLIND, Illinois Department of Public Health, and WARREN A. COOK, Associate Professor of Industrial Health, University of Michigan. KNOWLTON J. CAPLON, Industrial Ventilation Consultant, will give a comprehensive review of "Instruments for Measuring Air Velocity and Metering Air." CHARLES R. WILLIAMS, Ph.D., Liberty Mutual Insurance Company, Boston, will speak on "Instruments for Measuring Sound and Vibration." KARL Z. MORGAN, Director of Health Physics Division, Oak Ridge National Laboratory, will discuss the field of "Instruments for Measuring Ionizing Radiations." HUGH ARCHER, Consulting Engineer, The Archer-Reed Company, will speak on the subject of "Instruments for Measuring Ultraviolet, Visible and Infra-red Energy."

In addition, 19 technical papers will be given by authorities in specific instrumentation of the above fields. Manufacturers of instruments for industrial hygiene have been invited to exhibit and also to act as special faculty members during the week of the Symposium. Approximately 100 manufacturers will participate, as will 100 makers of "home-assembled" instruments.

An encyclopedia-type book will grow out of the Symposium. Papers presented at the Symposium will be published in this illustrated volume which will include the comprehensive review and technical papers, as well as data supplied by the makers of the instruments.

The Symposium and resulting publication is expected to fill a long felt need in the field of instrumentation for industrial hygiene. The University announces enthusiastic response from both manufacturers and "users" of industrial hygiene instruments.

Those interested in obtaining an information booklet about the Symposium should write to: H. E. MILLER, Director, Continued Education, 109 South Observatory St., Ann Arbor, Michigan.

Annual Meeting

THE 1954 Industrial Health Conference will be held at the Hotel Sherman, Chicago, April 24 to May 1. The AMERICAN INDUSTRIAL HYGIENE ASSOCIATION program starts Monday, April 26, and ends with the annual banquet and Cummings Memorial Lecture on Thursday, April 29.

The American Conference of Governmental Industrial Hygienists starts with committee meetings on Saturday, April 24, Round Table discussions on Sunday, and a formal program Monday morning. Monday afternoon will be devoted to committee reports. A business session will be held Tuesday noon.

The detailed AIHA program is as follows:

Monday, April 26

Registration.

Industrial Hygiene Tours: Transportation will be provided at a nominal fee (approximately $1.00). Buses will leave Hotel Sherman at 1:30 P.M. for all tours except the Swift and Company tour. The bus for the Swift and Company tour will leave at 11:30 A.M. as lunch will be served at the Swift plant.

1. Ekco Products Company—World's largest Manufacturer of Kitchen Utensils. Tour will include visits to all principal fabricating and finishing departments.
2. Swift and Company—Extended trip through hog slaughtering facility, dressing, et cetera. Also, trip through test kitchen if desired (maximum 50).
3. Underwriters Laboratories—Conducted tour in small groups with "fireworks" being provided for whatever tests are in progress at that time.
4. W. F. Hall Printing Company—One of World's largest Printers. The tour will include visits to bindery, handwork, magazine and press departments.

Tuesday, April 27

GENERAL SESSION:

Co-Chairmen: ANNA M. BAETJER, SC.D., Johns Hopkins School of Hygiene and Public Health, Baltimore, Maryland, and WILLIAM R. BRADLEY, American Cyanamid Company, New York, New York.

Welcome—HENRY F. SMYTH, JR., PH.D., Mellon Institute, Pittsburgh, President, AIHA.

"A Technique for Evaluating Industrial Skin Exposures"—G. M. WILKENING, Esso Laboratories, Standard Oil Development Company, Linden, New Jersey.

"Respiratory Gas Exchange in Relation to Pulmonary Performances"—THEODORE F. HATCH and KENNETH COOK, Department of Occupational Health, School of Public Health, University of Pittsburgh.

"Particle Size Classification of Solid and Liquid Aerosols by Electrostatic Precipitation"—EVELYN JETTER, HUGO DIGIOVANNI and MERRIL EISENBUD, U.S. Atomic Energy Commission, New York Operations Office, New York, New York.

Intermission—Visit Exhibits.

"Noise Dose—A New Concept for Assessing Industrial Noise Hazards"—K. C. STEWART, Department of Occupational Health, University of Pittsburgh.

"The Toxicity of Trichloroethylene-Extracted Soybean Oil Meal"—L. L. MCKINNEY, Northern Regional Research Laboratory, U.S. Department of Agriculture, Peoria, Illinois.

"Results of a Pretest Health Survey in the Detroit-Windsor International Air Pollution Study"—A. F. W. PEART, M.D., Epidemiology Division, Department of National Health and Welfare, Ottawa, Canada.

Local Sections Council Luncheon.

Joint Session—AIHA-ACGIH:

Co-Chairmen: HENRY F. SMYTH, JR., PH.D., Mellon Institute, Pittsburgh, and JOSEPH SHILEN, M.D., Bureau of Industrial Hygiene, Pennsylvania Department of Health, Harrisburg.

Board of Directors Meeting (Dinner).

Wednesday Morning, April 28

JOINT SESSION—AIHA-IMA:

Co-Chairmen: HOWARD N. SCHULZ, Abbott Laboratories, North Chicago, Illinois: President, Chicago Section, AIHA, and WILL F. LYON, M.D., President, Chicago Society of Industrial Medicine and Surgery. Topic—The Responsibility of the Professions in Health Education of the Employee.

"The Industrial Physician"—Speaker to be announced.

Discussion—WILLIAM R. BRADLEY, American Cyanamid Company, New York, New York.

"The Industrial Hygienist"—CLYDE M. BERRY, PH.D., Medical Department, Esso Standard Oil Company, Linden, New Jersey.

Discussion—Speaker to be announced.

Intermission—Visit Exhibits.

"The Industrial Nurse"—IRMA C. HEINZ, R.N., Committee on Education, American Association of Industrial Nurses, New York, New York.

Discussion—STANLEY JOHNSON, Secretary Illinois Federation of Labor, Chicago.

"The Industrial Psychologist"—W. A. EGGERT, PH.D., Chief Psychologist, Lumbermens Mutual Casualty Company, Chicago.

AIHA Annual Business Meeting.

Wednesday Afternoon, April 28

CONCURRENT SESSION—Air Pollution Division:

Session Arranger: GEORGE D. CLAYTON, U.S. Public Health Service, Detroit.

Co-Chairmen: PAUL D. HALLEY, Standard Oil Company of Indiana, Chicago, and LUCIEN E. RENES, Phillips Petroleum Company, Bartlesville, Oklahoma.

"The Effect of Several Industrial Gases on Plants with Special Reference to Hydrofluoric Acid Gas"—A. E. HITCHCOCK, PH.D., Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York.

"Air Pollution in the Area Surrounding a Blast Furnace—Slag Processing Plant"—J. CHOLAK, L. J. SCHAFER and D. YEAGER, Kettering Laboratory, College of Medicine, University of Cincinnati.

"Acute, Subacute and Chronic Effects of Experimental Exposure to Los Angeles Smog"—FALK, PH.D., Biochemistry Laboratory, School of Medicine, University of Southern California, Los Angeles.

"The Methodology of Detecting Microbial Air Pollution"—ALEXANDER GOETZ, PH.D., California Institute of Technology, Pasadena.

Intermission—Visit Exhibits.

"State Regulations on Air Pollutants"—J. F. BARKLEY, PH.D., Fuels Utilization Branch, U.S. Bureau of Mines, Washington, D.C.

"Preliminary Meteorological Findings and Their Influences on Air Pollution in the Detroit-Windsor Area"—HAROLD BAYNTON, Windsor Laboratories, International Joint Commission, Windsor, Ontario, Canada.

"Measurement and Identification of Aerosol Contaminants by Microscopic and X-Ray Diffraction Techniques" —MORRIS KATZ, PH.D., and V. C. SHORES, PH.D., Board on Air Pollution, International Joint Commission, Ottawa, Ontario, Canada.

Business Meeting.

CONCURRENT SESSION—Chemical and Analytical Division:

Session Arranger: RALPH G. SMITH, Bureau of Industrial Hygiene, Detroit Department of Health.

Co-Chairmen: KATHLEEN KUMLER, Industrial Hygiene Department, General Motors Corporation, Detroit, and ROBERT G. KEENAN, Division of Industrial Hygiene, U.S. Public Health Service, Cincinnati.

"Problems Encountered in X-Ray Diffraction Technique for Quantitative Analysis of Industrial Dust"—DONALD E. VAN FARROWE, Division of Industrial Health, Michigan Department of Health, Lansing.

"Some Improvements in the Fluorometric Determination of Beryllium"—CLAUDE W. SILL, Health and Safety Branch, Idaho Operations Office, U.S. Atomic Energy Commission, Idaho Falls.

"Reactions Useful in Determination of Chemical Composition of Liquid Aerosols"—FREDERICK A. FRANCH, U.S. Naval Radiological Defense Laboratory, San Francisco.

Intermission--Visit Exhibits.

"Respiratory Protection Against Decaborane"—WILLIAM H. HILL, Department of Occupational Health, University of Pittsburgh School of Public Health.

"Direct Field Determination of Lead in Air"—MARY O. AMDUR, PH.D., and LESLIE SILVERMAN, SC.D., Department of Industrial Hygiene, Harvard School of Public Health, Boston.

"A Field Method for the Determination of Formaldehyde in Air"—WILLIAM E. MACDONALD, JR., Division of Industrial Hygiene, Florida State Board of Health, Jacksonville.

Business Meeting.

CONCURRENT SESSION—Radiation Division:

Session Arranger: E. C. BARNES, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh.

Co-Chairmen: W. D. CLAUS, PH.D., Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C., and H. F. SCHULTE, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

"Lung Hazards from Radioactive Particles"—H. CEMBER, et al., University of Pittsburgh, Graduate School of Public Health, Pittsburgh.

"Studies on Lung Clearance of Radioactive Dust in Normal Irradiated and Vaccinated Rabbits"—G. V. TAPLIN, M.D., O. MERIDITH, H. KADE, C. FINNEGAN and MARGARET LANGFORD, University of California, West Los Angeles.

"A Model for the Distribution and Excretion of Uranium (+6)"—S. R. BERNARD, W. C. DEMARCUS, M. P. STARNES, J. C. GALLIMORE and E. C. STRUXNESS, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Intermission—Visit Exhibits.

"Sampling Criteria for Estimating Airborne Radioactive Particulate Hazards"—THOMAS J. BURNETT, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

"Investigations into the Toxicity of Polonium: Effects of Routes of Administration"—F. A. SMITH, P. E. MORRIS, L. J. CASARETT, R. DELLA ROSA and J. N. STANNARD, the University of Rochester, School of Medicine and Dentistry, Rochester, New York.

"The Acute Toxicity of Inhaled Radon"—D. A. MORKEN, the University of Rochester, School of Medicine and Dentistry, Rochester, New York.

Thursday Morning, April 29

CONCURRENT SESSION—Engineering Division:

Session Arranger: KENNETH W. NELSON, American Smelting and Refining Company, Salt Lake City.

Co-Chairmen: GEORGE S. REICHENBACH, JR., Bethlehem Steel Company, Sparrows Point, Maryland, and HENRY T. HERNDON, Texas Employers' Insurance Company, Dallas.

"Fog Type Scrubbers"—KERNAN, BRIAN and F. A. THOMAS, JR., School of Mechanical Engineering, Georgia Institute of Technology, Atlanta.

"Field Evaluation of Wet Fiber Filters for Treatment of Air Contaminants"—M. W. FIRST, SC.D., Consulting and Research Engineer, Newton Centre, Massachusetts, and R. P. WARREN, Buffalo Forge Company, Buffalo, New York.

"Cleaning Efficiency of FG-25 Filter Media for Atmospheric Dust"—D. P. O'NEIL and J. F. EGE, JR., Argonne National Laboratory, Lemont, Illinois.

Intermission—Visit Exhibits.

"Tests on Laboratory Fume Hoods"—E. C. HYATT, H. F. SCHULTE, H. JORDAN and R. MITCHELL, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

"Ventilation and Dust Control in Refining Uranium Ore and Concentrates"—H. I. MILLER, JR., Catalytic Construction Company, Philadelphia.

"Theoretically Required Exhaust Rates for Dust Control in Bulk Material Handling Systems"—W. C. L. HEMEON, Industrial Hygiene Foundation, Pittsburgh.

CONCURRENT SESSION—Radiation Division:

Session Arranger: E. C. BARNES, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh.

Co-Chairmen: To Be Announced.

"Radiation Hazards in Use of X-Ray Diffraction Equipment"—J. MCLAUGHLIN and HANSON BLATZ, U.S. Atomic Energy Commission, New York Operations Office, New York, New York.

"Radiation Problems from Microwave Power Tubes"—S. C. BALLARD and R. BANCROFT, Liberty Mutual Insurance Companies, Boston.

"Radium Capsules and Their Associated Hazards"—C. D. YAFFE, Division of Industrial Hygiene, U.S. Public Health Service, Cincinnati.

Intermission—Visit Exhibits.

"Radon Levels Found in Mines in New York State"—S. J. HARRIS, Division of Industrial Hygiene, New York State Department of Labor, New York, New York.

"Radioactive Dust and Gas in the Uranium Mines of Utah"—ELDRIDGE MORRILL, JR., Division of Occupational Health, Utah State Health Department, Salt Lake City.

"Determination of the Alpha Counting Efficiency of Some Filter Papers"—ROBERT F. BARKER, Health Division, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

"Investigations of Absorption Factors and Counting Efficiencies for Filter Media Used in Dust Sampling"—M. G. MASON, Mallinckrodt Chemical Works, St. Louis.

CONCURRENT SESSION—Toxicology Division:

Session Arranger: CHARLES H. HINE, M.D., University of California Medical Center, San Francisco.

Co-Chairmen: DAVID W. FASSETT, M.D., Kodak Park Works, Eastman Kodak Company, Rochester, New York, and H. E. STOKINGER, PH.D., Industrial Hygiene Field Headquarters, U.S. Public Health Service, Cincinnati.

"Response of Human Subjects to Inhalation of Sulfur Dioxide with Traces of Sulfuric Acid Mist"—MARY O. AMDUR and PHILIP DRINKER, Industrial Hygiene Laboratory, School of Public Health, Harvard School of Public Health, Boston.

"Studies on the Pathologic Effects of Coal Dust and Smoke on the Lungs of Animals"—ANNA M. BAETJER, SC.D., Johns Hopkins School of Hygiene and Public Health, Baltimore.

"Prophylactic and Therapeutic Value of Reticuloendothelial System Stimulation in the Management of Acute Whole-Body Roentgen Radiation Injury in Laboratory Animals"—G. V. TAPLIN, M.D., O. MERIDITH, H. KADE, C. FINNEGAN and MARGARET LANGFORD, University of California, West Los Angeles.

"Comparative Toxicity of Thermal Decomposition Products of SF_6 and other Gases"—E. D. PALMES, N. NELSON and H. W. GORDON, Institute of Industrial Medicine, New

York University Bellevue Medical Center, New York, New York.

Intermission—Visit Exhibits.

"The Toxicity Resulting from Thermal Decomposition of Certain Organic Substances"—J. F. TREON, The Kettering Laboratory, University of Cincinnati College of Medicine.

"Problems of Health in the Marketing of Chemicals"—E. M. ADAMS, PH.D., Biochemical Research Department, The Dow Chemical Company, Midland, Michigan.

"Studies on the Toxicology of Ethylene and Propylene Oxide"—K. H. JACOBSON, Chemical Corps Medical Laboratory, Army Chemical Center, Maryland.

"Studies on the Lung-Irritating Properties of Diatomaceous Earth in Guinea Pigs"—B. D. TEBBENS, SC.D., R. R. BEARD, M.D., School of Public Health, University of California, Berkeley.

Thursday Afternoon, April 29

CONCURRENT SESSION—Engineering Division:

Session Arranger: KENNETH W. NELSON, American Smelting and Refining Company, Salt Lake City.

Co-Chairmen: J. F. KNUDSEN, Industrial Hygiene Department, Kennecott Copper Corporation, Salt Lake City, and K. R. DOREMUS, Industrial Health and Research Section, Merck and Company, Rahway, New Jersey.

"Collection Efficiency Studies of Air Cleaning and Air Sampling Filter Media"—C. G. DETWILER and J. J. FITZGERALD, Knolls Atomic Power Laboratory, General Electric Company, Schenectady, New York.

"Preliminary Report on a Noise Study in Federal Prisons"—C. D. YAFFE, Division of Industrial Hygiene, U.S. Public Health Service, Cincinnati.

"Engineering Controls in a Beryllium Production Plant"—A. J. BRESLIN and W. B. HARRIS, U.S. Atomic Energy Commission, New York Operations Office, New York, New York.

Intermission—Visit Exhibits.

"Industrial Hygiene Program for a Benzene Extraction Plant in a Petroleum Refinery"—F. S. VENABLE, Esso Standard Oil Company, Baton Rouge, Louisiana.

"An Automatic H_2S Alarm"—KENNETH W. NELSON, American Smelting and Refining Company, Salt Lake City and I. L. BEAUCHAMP, Harvard School of Public Health, Boston.

"Absolute Control of Chromic Acid Mist from Electroplating by a New Type of Surface Active Agent"—GEORGE HAMA, W. G. FREDERICK and HARRY BROWN, Detroit Department of Health.

Business Meeting.

CONCURRENT SESSION—Radiation Division:

Session Arranger: E. C. BARNES, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh.

Co-Chairmen: K. Z. MORGAN, PH.D., Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee and FORREST WESTERN, PH.D., Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C.

"Batch Processing of Film for Radiation Protection of Personnel"—R. G. MAGILL, Division of Radiation Safety, University Health Department, University of California, Berkeley.

"Recent Developments in Chemical Dosimetry and Application in Health Physics and Civil Defense"— G. V. TAPLIN, M.D., S. C. SIGOLOFF and C. H. DOUGLAS, University of California, West Los Angeles.

"A Method for Measuring Thoron in Air"—SIMON SHALER, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Intermission—Visit Exhibits.

"Determination of Curie Content of Solid Wastes for Sea Burial"—F. B. OLESON and F. P. COWAN, Health Physics Division, Brookhaven National Laboratory, Upton, Long Island, New York.

"The Sale to Commercial Channels of Scrap Carbon Steel Contaminated with Uranium"—H. J. MCALDUFF, Biology Branch, Research and Medicine Division, U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

"Decontamination of Buildings Used for Processing Alpha Emitters"—PAUL KLEVIN, WILLIAM B. HARRIS and HANSON BLATZ, U.S. Atomic Energy Commission, New York Operations Office, New York, New York.

Business Meeting.

CONCURRENT SESSION—Toxicology Division:

Session Arranger: CHARLES H. HINE, M.D., University of California, Medical Center, San Francisco.

Co-Chairmen: C. P. CARPENTER, PH.D., Mellon Institute, Pittsburgh, and CHARLES L. HAZLETON, American Optical Company, Southbridge, Massachusetts.

"The Toxicological Aspects of Cholinesterase Inhibitors as Industrial Hazards"—L. W. HAZLETON, Hazleton Laboratories, Falls Church, Virginia.

"Toxicology of EPN"— H. C. HODGE, University of Rochester, School of Medicine and Dentistry, Rochester, New York.

"Toxicity of Ozone, Experimental Findings on a Disputed Role of Associated Nitrogen Oxides"—H. E. STOKINGER, D. H. BYERS, B. E. SALTZMAN, F. L. HYSLOP and W. D. WAGNER, Occupational Health Field Headquarters, U.S. Public Health Service, Cincinnati.

"Toxicological Appraisal of, and Safe-Handling Procedures for EPON Resins"—CHARLES H. HINE, M.D., H. H. ANDERSON, J. K. KODAMA and H. JANG, Department of Pharmacology and Experimental Therapeutics, University of California, School of Medicine, San Francisco.

Intermission—Visit Exhibits.

Subject to be announced—V. K. ROWE, et al., Dow Chemical Company, Midland, Michigan.

"A New Technique for the Measurement of Aerosol Retention in the Human Lung"—B. ALTSHULER, L. YARMUS, E. D. PALMES and N. NELSON, Institute of Industrial Medicine, New York University Bellevue Medical Center, New York, New York.

"Further Observations on the Inhalation of Lead by Man"—R. A. KEHOE, M.D., Kettering Laboratory, University of Cincinnati College of Medicine, Cincinnati.

Business Meeting.

Thursday Evening, April 29

Annual Banquet:

Donald E. Cummings Memorial Lecture (Title to be announced)—FRANK A. PATTY, Industrial Hygiene Department, General Motors Corporation, Detroit.

THE INDUSTRIAL HYGIENE FOUNDATION, and the University of Pittsburgh's Graduate School of Public Health and School of Medicine were sponsors of "A Short Course on Noise and Its Effect on Hearing," which was offered on eight consecutive Monday afternoons January 4 through February 22 at the Graduate School of Public Health. The course was designed specifically for hygienists, physicians, safety engineers and design engineers.

✦ News of the Local Sections

New Jersey Section

THE NEW JERSEY SECTION was the host for the Seventh Annual Tri-Section Industrial Health Conference held in conjunction with the Metropolitan New York and Philadelphia Sections on December 4. The conference, held in Newark, included an afternoon and evening session. DR. MIRIAM SACHS, Chief of the Bureau of Industrial Health, New Jersey Department of Health, was in charge of the program as follows: "The Industrial Medical Program of the Frankford Arsenal,"—L. P. DELVIN, M.D., Medical Director, Frankford Arsenal; "Design Criteria in Industrial Heating, Ventilation and Dust Control,"—MARTIN A. O'NEILL, Project Engineer, Catalytic Construction Company; "The Significance of Weighted Samples in Evaluation of Industrial Hygiene Exposures,"—PAUL KLEVIN, Atomic Energy Commission; "Current Status of the Lead Problem in Industrial Hygiene,"—WILLIAM C. WILENTZ, Perth Amboy, New Jersey; "Control of Variables in Air Sanitation Measurements by Means of an Automatic Directional Air Sampler,"—WILLIAM A. MUNROE, Principal Public Health Engineer, Bureau of Industrial Hygiene, New Jersey Department of Health; "Toxicological Data, Sources of Information and Future Needs,"—HENRY F. SMYTH, JR., Ph.D., President, AIHA.

Michigan Section

THE MEMBERS of the Michigan Section were the guests of the Pontiac Motors Division, General Motors Corporation, on February 9, 1954. The meeting consisted of a dinner and a tour of the Pontiac assembly plant.

Chicago Section

THE DECEMBER 2 meeting of the Chicago Section consisted of a panel discussion on topics submitted by the membership. Questions on many phases of industrial health—medical, engineering, chemical, nursing, air pollution, sanitation and compensation, were answered by the panel members.

A joint meeting of the Chicago Section and the Greater Chicago Chapter ASSE was held on January 6. The program was devoted to "gadgets," i.e., non-commercial devices which have an industrial hygiene or safety application. A number of working models and a great many photographs were shown. DR. FLOYD VAN ATTA, National Safety Council, served as chairman of the program.

"Common Industrial Hygiene Problems" was the subject of the February 3 meeting. The topic was presented from the viewpoint of the governmental agency, the insurance carrier, and the private consultant. The speakers were ARVID TIENSON, Illinois Department of Labor; FRED COOK, Bituminous Casualty Corporation; and LYNN D. WILSON, Wilson Industrial Hygiene and Research Laboratories.

St. Louis Section

THE JANUARY 26 meeting of the St. Louis Section was held in the Melbourne Hotel. J. H. CARTER, Commissioner, Division of Smoke Regulation, Department of Public Safety, City of St. Louis, spoke on "Opportunities in the Field of Air Pollution Control." MR. CARTER emphasized the fact that accomplishment in elimination or control of air pollution depends on the coordinated efforts of experts in the fields of many sciences and professions.

Ohio Valley Section

THE OHIO VALLEY Section held its annual meeting on Wednesday, January 27 in Cincinnati. The group heard DR. HENRY F. SMYTH, JR. speak on the topic "Testing New Chemicals for Toxicity." DR. SMYTH, president of AIHA, and associated with the Mellon Institute, discussed methods and procedures employed at the Institute in studying toxicities of chemical compounds.

Metropolitan New York Section

THE METROPOLITAN New York Section met on February 8. The subject "Asbestosis—Medical and Industrial Hygiene Aspects" was discussed by DR. KENNETH W. SMITH, Medical Director, and H. M. JACKSON, Manager of Industrial Health Program, Johns-Manville Corporation.

DR. SMITH outlined what is known of the incidence, occurrence and medical phases of this type of pneumoconiosis. MR. JACKSON presented information concerning asbestos dust produced in manufacturing and mining operations as well as the methods used to control the dust and prevent disease caused by its inhalation.

New England Section

THE NEW ENGLAND Section held its annual meeting in Boston on December 29 and 30 with AAAS. Two joint sessions of AIHA and AAAS, Section P, and one session of AIHA and AAAS,

Section N, were held. The program of the joint sessions was as follows: "State of the Association," DR. HENRY F. SMYTH, JR., President, AIHA; "Exposure to Methanol from Spirit Duplicating Machines,"—R. G. MCALLISTER, Industrial Hygienist, Liberty Mutual Insurance Company; "Protective Creams,"—DR. GEORGE MORRIS, 520 Commonwealth Avenue; "The Odor Chemist in Industry,"—NICHOLAS DEININGER, Flavor Laboratory, Arthur D. Little Corporation; "New Developments in Air Cleaners,"—DR. LESLIE SILVERMAN, Harvard School of Public Health; "Radiological Safety in Food Sterilization,"—SAMUEL LEVIN, Radiological Safety Office, Occupational Medicine Service, Massachusetts Institute of Technology; "Effects of Combinations of Sulphuric Acid Mists and Sulphur Dioxide on Guinea Pigs,"—DR. MARY AMDUR, Harvard School of Public Health; "Lead and Coproporphyrin Excretion of Patients Treated with E.D.T.A.,"—BENJAMIN P. W. RUOTOLO, Chemist, and DR. HERVEY B. ELKINS, Chief of Laboratory, Massachusetts Division of Occupational Hygiene; "Practical Approach to Noise Control,"—HERBERT T. WALWORTH, Director of Industrial Hygiene, Lumbermens Mutual Casualty Company; "Effect on Skin of Radiation from Welding,"—DR. ROBERT THOMPSON, General Electric Company and JOHN FERRY, General Electric Company; "Investigation of Use of Versine for Chrome Ulcers and Lime Burns of Eye,"—DR. C. C. MALOOF, Medical Director, A. C. Lawrence Leather Company; "Clinical Usefulness of Calcium E.D.T.A. in Adult Lead Poisoning,"—DR. WILLIAM BAKER, Massachusetts General Hospital; "X-Radiation from Power Tubes in Electronic Industry,"—STANLEY BALLARD, Industrial Hygienist, Liberty Mutual Insurance Company; "Public Health Aspect of Atomic Power Development," DR. SHIELDS WARREN, Pathologist, N. E. Deaconess Hospital; Professor Pathology, Harvard Medical School; Consultant, U.S. Atomic Energy Commission.

✦ In the News

AFTER 20 years of association with the Saranac Laboratory and the Trudeau Foundation, DR. ARTHUR J. VORWALD, in July, 1953, resigned from that organization. On March 1, 1954 he will assume a position, in Detroit, as Professor and Director of the new Department of Industrial Medicine and Hygiene in the College of Medicine at Wayne University. The University has also extended to DR. VORWALD the privilege for consulting practice.

HERBERT K. ABRAMS, M.D., Medical Director for the Union Health Service of Chicago, Inc., has been appointed clinical Assistant Professor of Public Health at the College of Medicine, University of Illinois.

HEINRICH BRIEGER, M.D., Dr., P.H., Professor of Industrial Medicine, Jefferson Medical College, has been appointed consultant to the Williams Toxicology Laboratories, Inc. He will direct and supervise the execution of all projects, including toxicologic tests and original research.

PAUL D. HALLEY has been appointed Industrial Hygienist for the Standard Oil Company of Indiana and is making his headquarters in Chicago. He was formerly Acting Associate Director of the Bureau of Industrial Hygiene, West Virginia Department of Health.

CHARLES R. WILLIAMS, M.D., has been appointed Director of Industrial Hygiene for Liberty Mutual Insurance Company, Boston. He was formerly Director of Applied Research for Liberty Mutual. He is also Assistant Professor of Industrial Hygiene at Harvard University.

✦ Obituary

WILLIAM E. WILSON, 28, Industrial Hygienist with Lumbermens Mutual Casualty Company of Chicago, died January 7, 1954, of complications following an appendectomy.

MR. WILSON was born November 16, 1925 in Brooklyn, New York. He attended public schools in Blue Island, Illinois and served 20 months with the U.S. Air Force. In 1949, he was graduated from the University of Illinois, and did graduate work at the University of New Mexico in 1950.

Prior to his service with Lumbermens, MR. WILSON was employed by the Los Alamos Scientific Laboratory at Los Alamos, New Mexico. Aside from his memberships in various technical organizations he was an enthuiastic worker for the Boy Scouts of America.

He is survived by his wife, a son three years old and a daughter four months old. His passing is keenly felt. The AIHA will miss this promising young member and a true friend.

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